PB80-202997

Electric Arc Furnaces in Ferrous Foundries
Background Information for Proposed Standards

(U.S.) Environmental Protection Agency
Research Triangle Park, NC

May 80

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-80-020a
May 1980

PB80-202997

Air

EPA

Electric Arc Furnaces in Ferrous Foundries — Background Information for Proposed Standards

Draft EIS

NSPS

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-80-020a	2.	3. RECIPIENT'S ACCESSION NO. PB80 202997
4. TITLE AND SUBTITLE Electric Arc Furnaces in Ferrous Foundries - Background Information for Proposed Standards		5. REPORT DATE May 1980 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards Environmental Protection Agency Research Triangle Park, North Carolina 27711		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-02-3059
12. SPONSORING AGENCY NAME AND ADDRESS DAA for Air Quality Planning and Standards Office of Air, Noise, and Radiation U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED 14. SPONSORING AGENCY CODE EPA/200/04
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Standards of Performance for the control of emissions from electric arc furnaces in ferrous foundries are being proposed under the authority of Section 111 of the Clean Air Act. These standards would only apply during periods of melting and refining in the furnace. This document contains background information and environmental and economic impact assessments of the regulatory alternatives considered in developing proposed standards.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution Pollution control Standards of performance Ferrous foundries Electric arc furnaces particulates	Air Pollution Control	13 B
18. DISTRIBUTION STATEMENT unlimited	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-450/3-80-020a

Electric Arc Furnaces in Ferrous Foundries — Background Information for Proposed Standards

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

May 1980

i.a

This report has been reviewed by the Emission Standards and Engineering Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, or from National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

Publication No. EPA-450/3-80-020a

Background Information
and Draft
Environmental Impact Statement
for Electric Arc Furnaces in
Ferrous Foundries

Type of Action: Administrative

Prepared by:

Don R Goodwin 5/30/80

Don R. Goodwin (Date)
Director, Emission Standards and Engineering Division
Environmental Protection Agency
Research Triangle Park, N. C. 27711

Approved by:

David G Hawkins 6/17/80

David G. Hawkins (Date)
Assistant Administrator for Air, Noise, and Radiation
Environmental Protection Agency
Washington, D. C. 20460

Draft Statement Submitted to EPA's
Office of Federal Activities for Review on July 1980
(Date)

This document may be reveiwed at:

Central Docket Section
Room 2902, Waterside Mall
Environmental Protection Agency
401 M Street, S.W.
Washington, D. C. 20460

Additional copies may be obtained at:

Environmental Protection Agency Library (MD-35)
Research Triangle Park, N. C. 27711

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

TABLE OF CONTENTS

Section Title Page

List of Figures v

List of Tables vii

CHAPTER 1 SUMMARY 1-1

1.1 Regulatory Alternatives 1-1

1.2 Environmental Impact 1-2

1.3 Economic Impact 1-2

CHAPTER 2 INTRODUCTION 2-1

2.1 Background and Authority for Standards 2-1

2.2 Selection of Categories of Stationary Sources 2-5

2.3 Procedure for Development of Standards of Performance 2-6

2.4 Consideration of Costs 2-9

2.5 Consideration of Environmental Impacts 2-10

2.6 Impact on Existing Sources 2-11

2.7 Revision of Standards of Performance 2-11

CHAPTER 3 THE IRON AND STEEL FOUNDRY INDUSTRY PROCESSES AND POLLUTANT EMISSIONS 3-1

3.1 General 3-1

3.2 Iron and Steel Foundry Processes and Emissions . . . 3-9

3.3 Baseline Emissions 3-30

3.4 References for Chapter 3 3-41

CHAPTER 4 EMISSION CONTROL TECHNIQUES 4-1

4.1 Introduction 4-1

4.2 Control of Charging Emissions 4-2

4.3 Control of Melting and Refining Emissions 4-29

TABLE OF CONTENTS (continued)

Section	Title	Page
4.4	Control of Tapping Emissions	4-37
4.5	Exhaust Gas Cleaning Devices	4-42
4.6	Emission Source Test Data	4-47
4.7	References for Chapter 4	4-54
CHAPTER 5	MODIFICATION AND RECONSTRUCTION OF IRON AND STEEL FOUNDRIES	5-1
5.1	Provisions for Modification and Reconstruction . . .	5-2
5.2	Applicability to Electric Arc Furnaces in the Iron and Steel Foundry Industry	5-3
CHAPTER 6	MODEL PLANTS AND REGULATORY ALTERNATIVES	6-1
6.1	Introduction	6-1
6.2	Model Plants	6-1
6.3	Regulatory Alternatives	6-4
6.4	References for Chapter 6	6-8
CHAPTER 7	ENVIRONMENTAL IMPACT	7-1
7.1	Air Pollution Impact	7-1
7.2	Water Pollution Impact	7-13
7.3	Solid Waste Disposal Impact	7-24
7.4	Energy Impact	7-28
7.5	Other Environmental Impacts	7-28
7.6	Other Environmental Concerns	7-28
7.7	References for Chapter 7	7-30
CHAPTER 8	ECONOMIC IMPACT	8-1
8.1	Industry Characterization	8-1
8.2	Cost Analysis of Control Options	8-15

TABLE OF CONTENTS (concluded)

Section	Title	Page
8.3	Other Cost Considerations	8-27
8.4	Economic Impact of Regulatory Alternatives	8-29
8.5	Potential Socioeconomic Impacts	8-44
8.6	References for Chapter 8	8-47
APPENDIX A	EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT	A-1
APPENDIX B	INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS	B-1
APPENDIX C	EMISSION TEST DATA FOR FABRIC FILTERS ON ELECTRIC ARC FURNACES AT IRON AND STEEL FOUNDRIES	C-1
C.1	Emission Levels From Fabric Filters at Iron Electric Arc Furnaces	C-1
C.2	Particulate Emission Levels From Fabric Filters at Steel Electric Arc Furnaces.	C-10
C.3	Visible Emission Observations of Process Emissions at Steel Foundries	C-15
C.4	Visible Emission Observations of Emission Capture Devices at Steel Foundries	C-17
C.5	References for Appendix C	C-70
APPENDIX D	EMISSION MEASUREMENT AND CONTINUOUS MONITORING . . .	D-1
D.1	Emission Measurement Methods	D-1
D.2	Monitoring Systems and Devices	D-2
D.3	Performance Test Methods	D-3
D.4	References for Appendix D	D-4

LIST OF FIGURES

Figure	Title	Page
Figure 3-1	Iron and Steel Foundry Process Flow and Emission Sources	3-10
Figure 3-2	Emissions From Electric Arc Furnace Operation	3-14
Figure 4-1	Canopy Hood Using Building Roof as Part of the Canopy, Combined with Direct Furnace Evacuation	4-4
Figure 4-2	Design Aspects of Building Evacuation System	4-9
Figure 4-3	Schematic Diagram of Bay Evacuation System	4-12
Figure 4-4	Sketch of Furnace Enclosure Design at Lone Star Steel Co.	4-14
Figure 4-5	Krupp Furnace--Sequence of Events During Charging	4-19
Figure 4-6	Hawley Close Capture Hood	4-21
Figure 4-7	The Brusa Charging and Preheating System	4-26
Figure 4-8	Hooded Charge Bucket	4-27
Figure 4-9	Marchand Design for Charging Emission Control	4-28
Figure 4-10	Roof Hood	4-30
Figure 4-11	Side Draft Hood	4-33
Figure 4-12	Direct Evacuation Through Fourth Hole	4-35
Figure 4-13	ARMCo Incorporated Design for Tapping Pit Enclosure	4-38
Figure 4-14	Proposed Ladle Car and Ladle Enclosure by Marchand	4-40
Figure 4-15	Mobile Tapping Hoods	4-41
Figure 4-16	Summary of Source Test Data for Baghouses on EAF's Producing Iron	4-49
Figure 4-17	Summary of Source Test Data for Baghouses on EAF's Producing Steel	4-51

LIST OF FIGURES (concluded)

Figure	Title	Page
Figure 7-1	Proposed Scrubber Wastewater Treatment System . . .	7-23
Figure C-1	Summary of Source Test Data for Baghouses on EAF's Producing Iron	C-2
Figure C-2	Summary of Source Test Data for Baghouses on EAF's Producing Steel	C-11

LIST OF TABLES

Table	Title	Page
Table 1-1	Matrix of Environmental and Economic Impacts for Regulatory Alternatives	1-3
Table 3-1	Range of Compositions for Typical Cast Irons . . .	3-2
Table 3-2	End-Use Distribution of Castings	3-3
Table 3-3	Summary of Foundries by State	3-5
Table 3-4	Foundry Industry Data and Projections	3-8
Table 3-5	Raw Materials Used for Iron and Steel Production	3-11
Table 3-6	Chemical Analysis of Particulate Emissions from an Electric Arc Furnace	3-26
Table 3-7	Composition of Dust Collected by Fabric Filters at an Iron Foundry	3-27
Table 3-8	Particle Size Distribution for Particulate Emissions From Electric Arc Furnaces at Three Iron Foundries	3-28
Table 3-9	Steel Electric Arc Furnace Dust Composition	3-29
Table 3-10	Summary of Emission Factors for Iron- and Steel-Producing Electric Arc Furnaces	3-31
Table 3-11	Summary of State Air Pollution Regulations	3-32
Table 3-12	Mass Emission Rates for Iron and Steel Foundries	3-40
Table 4-1	Typical Exhaust Flow Rates and Emission Capture Efficiency of Charging and Tapping Control Devices at Model Foundries	4-7
Table 4-2	Design Data for Lone Star Steel Company Furnace Enclosure	4-15
Table 4-3	Design Data for Certified Alloy Products Furnace Enclosure	4-18
Table 4-4	Typical Exhaust Flow Rates and Emission Capture Efficiency of Melting Control Systems	4-32

LIST OF TABLES (continued)

Table	Title	Page
Table 6-1	Model Plant Parameters - Common	6-2
Table 6-2	Model Plant Parameters - Specific	6-3
Table 6-3	Regulatory Alternatives and Control System Options	6-6
Table 7-1	Summary of National Air Pollution Impact	7-3
Table 7-2	Source Data for Dispersion Modeling	7-5
Table 7-3	Highest Second-High, 24-hour Particulate Concentration Impacts From Electric Arc Furnaces (Oklahoma City, Oklahoma - Baseline)	7-8
Table 7-4	Highest Second-High, 24-Hour Particulate Concentration Impacts From Electric Arc Furnaces (Oklahoma City, Oklahoma - NSPS)	7-9
Table 7-5	Highest Second-High, 24-hour Particulate Concentration Impacts From Electric Arc Furnaces (Pittsburgh, Pennsylvania - Baseline)	7-10
Table 7-6	Highest Second-High, 24-hour Particulate Concentration Impacts From Electric Arc Furnaces (Pittsburgh, Pennsylvania - NSPS)	7-11
Table 7-7	Summary of 24-hour Concentration Impacts From New Sources	7-12
Table 7-8	Maximum Annual Geometric Mean Particulate Concentration Impacts From Electric Arc Furnaces (Oklahoma City, Oklahoma - Baseline)	7-14
Table 7-9	Maximum Annual Geometric Mean Particulate Concentration Impacts From Electric Arc Furnaces (Oklahoma City, Oklahoma - NSPS)	7-15
Table 7-10	Maximum Annual Geometric Mean Particulate Concentration Impacts From Electric Arc Furnaces (Pittsburgh, Pennsylvania - Baseline)	7-16
Table 7-11	Maximum Annual Geometric Mean Particulate Concentration Impacts From Electric Arc Furnaces (Pittsburgh, Pennsylvania - NSPS)	7-17
Table 7-12	Summary of Annual Geometric Mean Concentration Impacts From New Sources	7-18

LIST OF TABLES (continued)

Table	Title	Page
Table 7-13	Categories of Pollutants Which Might Be Found in an EAF Scrubber System Effluent	7-20
Table 7-14	Summary of Wet Scrubber Solids Collection	7-22
Table 7-15	Summary of Solid Waste Generation	7-25
Table 7-16	Trace Metallic Components of Baghouse Hopper Dust	7-27
Table 8-1	End-Use Distribution of Castings	8-2
Table 8-2	Summary of Foundries by State	8-4
Table 8-3	Ferrous Castings: Trends and Projections 1972-1983	8-10
Table 8-4	Estimated Year-End Foundry Electric Arc Furnace Capacity	8-16
Table 8-5	Expansions in Electric Arc Furnace Facilities	8-17
Table 8-6	Model Plant Parameters - Common	8-18
Table 8-7	Model Plant Parameters - Specific	8-19
Table 8-8	Regulatory Alternatives and Control System Options	8-20
Table 8-9	Capital Cost Estimates for Regulatory Alternatives	8-22
Table 8-10	Annualized Cost Estimates for Regulatory Alternatives	8-24
Table 8-11	Marginal Cost Effectiveness of the Second Alternative	8-25
Table 8-12	Base Cost of Installing Electric Arc Furnaces in Foundries	8-26
Table 8-13	Derived Income Statement and Balance Sheet Data for Baseline Model Plants	8-32
Table 8-14	Profitability Impact Analysis for Iron Model Plants Meeting Requirements of Second Alternative	8-34

LIST OF TABLES (continued)

Table	Title	Page
Table 8-15	Profitability Impact Analysis for Steel Model Plants Meeting Requirements of Second Alternative .	8-36
Table 8-16	Price Impact Analysis for Iron Model Plants Meeting Requirements of Second Alternative	8-42
Table 8-17	Price Impact Analysis for Steel Model Plants Meeting Requirements of Second Alternative	8-43
Table A-1	Evolution of the Background Information Document	A-1
Table B-1	Cross-Indexed Reference System to Highlight Environmental Impact Portions of the Document . . .	B-2
Table C-1	Summary of Visible Emission Data for EAF's Producing Iron	C-3
Table C-2	Summary of Visible Emission Data for EAF's Producing Steel	C-16
Table C-3	Summary of Particulate Results: Facility A (Baghouse Inlet)	C-18
Table C-4	Summary of Particulate Results: Facility A (Baghouse Outlet)	C-19
Table C-5	Summary of Particulate Results: Facility B (Baghouse Outlet)	C-20
Table C-6	Summary of Particulate Results: Facility C (Baghouse Outlet)	C-21
Table C-7	Summary of Particulate Results: Facility D (Baghouse Inlet)	C-22
Table C-8	Summary of Particulate Results: Facility D (Baghouse Outlet)	C-23
Table C-9	Summary of Particulate Results: Facility E (Baghouse Outlet)	C-24
Table C-10	Summary of Particulate Results: Facility F (Baghouse Outlet)	C-25
Table C-11	Summary of Visible Emissions: Facility A	C-26

LIST OF TABLES (continued)

Table	Title	Page
Table C-12	Summary of Visible Emissions: Facility A	C-28
Table C-13	Summary of Visible Emissions: Facility A	C-29
Table C-14	Summary of Visible Emissions: Facility A	C-30
Table C-15	Summary of Visible Emissions: Facility A	C-31
Table C-16	Summary of Visible Emissions: Facility A	C-32
Table C-17	Summary of Visible Emissions: Facility A	C-33
Table C-18	Summary of Visible Emissions: Facility A	C-34
Table C-19	Summary of Visible Emissions: Facility B	C-35
Table C-20	Summary of Visible Emissions: Facility B	C-36
Table C-21	Summary of Visible Emissions: Facility B	C-37
Table C-22	Summary of Visible Emissions: Facility B	C-38
Table C-23	Summary of Visible Emissions: Facility B	C-39
Table C-24	Summary of Visible Emissions: Facility B	C-40
Table C-25	Summary of Visible Emissions: Facility C	C-41
Table C-26	Summary of Visible Emissions: Facility C	C-42
Table C-27	Summary of Visible Emissions: Facility C	C-43
Table C-28	Summary of Visible Emissions: Facility C	C-44
Table C-29	Summary of Visible Emissions: Facility C	C-45
Table C-30	Summary of Visible Emissions: Facility C	C-46
Table C-31	Summary of Visible Emissions: Facility D	C-47
Table C-32	Summary of Visible Emissions: Facility D	C-48
Table C-33	Summary of Visible Emissions: Facility D	C-49
Table C-34	Summary of Visible Emissions: Facility D	C-50
Table C-35	Summary of Visible Emissions: Facility D	C-51

LIST OF TABLES (concluded)

Table	Title	Page
Table C-36	Summary of Visible Emissions: Facility D	C-52
Table C-37	Summary of Visible Emissions: Facility D	C-53
Table C-38	Summary of Gaseous Results: Facility A	C-54
Table C-39	Summary of Gaseous Results: Facility B	C-55
Table C-40	Summary of Gaseous Results: Facility C	C-56
Table C-41	Summary of Gaseous Results: Facility D	C-57
Table C-42	Summary of Particulate Results: Steel Furnaces (United States)	C-58
Table C-43	Summary of Visible Emissions: Facility G	C-59
Table C-44	Summary of Visible Emissions: Facility G	C-60
Table C-45	Summary of Visible Emissions: Facility G	C-61
Table C-46	Summary of Visible Emissions: Facility G	C-62
Table C-47	Summary of Visible Emissions: Facility G	C-63
Table C-48	Summary of Visible Emissions: Facility G	C-64
Table C-49	Summary of Visible Emissions: Facility I	C-65
Table C-50	Summary of Visible Emissions: Facility I	C-66
Table C-51	Summary of Visible Emissions: Facility I	C-67
Table C-52	Summary of Visible Emissions: Facility I	C-68
Table C-53	Summary of Tapping Pit Enclosure Emissions	C-69

1. SUMMARY

1.1 REGULATORY ALTERNATIVES

Standards of performance for new stationary sources are developed under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended. Section 111 requires the establishment of standards of performance for new stationary sources which ". . . may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare." The Act requires standards of performance for such sources to ". . . reflect the degree of emission limitation and the percentage reduction achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact, and energy requirements) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which starts after regulations are proposed in the *Federal Register*.

Two regulatory alternatives were selected for study. The first alternative would require no additional federal regulatory action. Only state and local regulations would be applicable to new sources. This alternative is considered to be the baseline condition from which the impacts of the other alternative are calculated. The second alternative would require Federal regulatory action and would place a more stringent limitation on the allowable level of particulate and visible emissions than that allowed by the baseline condition. The same emission capture and control systems could be used for the second alternative as for the first, but better maintenance of the entire system would be required.

1.2 ENVIRONMENTAL IMPACT

Regulatory Alternative 2 would have a beneficial impact on air quality. The projected decrease in annual emissions in the fifth year would be approximately 600 Mg/yr (675 tons/yr), a 50 percent reduction below the emission level of the baseline condition. There would be a negligible adverse solid waste impact; the projected annual increase above baseline in the fifth year would be approximately 600 Mg/yr (675 tons/yr), a 15 percent increase. There would be a negligible adverse impact on energy and water and no impact on noise. The impacts associated with Regulatory Alternative 2 are summarized in Table 1-1.

1.3 ECONOMIC IMPACT

Regulatory Alternative 2 would result in a worst-case product price increase of approximately 0.3 percent, including monitoring costs. There would be no significant effect on the growth of the foundry industry or of the electric arc furnace segment.

TABLE 1-1. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS FOR REGULATORY ALTERNATIVES

Administrative action	Air impact	Water impact	Solid waste impact	Energy impact	Noise impact	Economic impact
Alternative 1	0	0	0	0	0	0
Alternative 2	+2**	-1**	-1**	-1**	0	-1**

Key:

+	Beneficial impact.
-	Adverse impact.
0	No impact.
1	Negligible impact.
2	Small impact.
3	Moderate impact.
4	Large impact.
*	Short-term impact.
**	Long-term impact.
***	Irreversible impact.

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by EPA in the development of the proposed standard.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereinafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts, and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

   a. 25 percent of the listed categories by August 7, 1980
   b. 75 percent of the listed categories by August 7, 1981
   c. 100 percent of the listed categories by August 7, 1982

A governor of a State may apply to the Administrator to add a category which is not on the list or may apply to the Administrator to have a standard of performance revised.

2. EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.

3. EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

4. The term "standards of performance" is redefined, and a new term, "technological system of continuous emission reduction," is defined. The new definitions clarify that the control system must be continuous and may include a low- or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under Section 111 of the Act is extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impacts, and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards enhance the potential for long-term growth. Third, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term best available control technology (BACT), as defined in the Act, means

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or

> treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to Sections 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, Section 111(i) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety; (4) the governor of the State where the source is located consents; and (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards with a mandatory progress schedule.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are emitted then by stationary sources. Source categories which emit these pollutants were evaluated and ranked by a process involving such factors as: (1) the level of emission control (if any) already required by state regulations; (2) estimated levels of control that might be required from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected on these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all source categories not yet listed by EPA. These are: (1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible immediately to develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the nonair quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction which has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standard of performance.

During the information-gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standard with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D.C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a promulgation package, which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of: (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance; (2) the potential inflationary or recessionary effects of the regulation; (3) the effects the regulation might have on small business with respect to competition; (4) the effects of the regulation on consumer costs; and (5) the effects of the regulation on energy use. Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and by comparison with of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is taken because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact of the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decisionmaking process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counterproductive environmental effects of a proposed standard as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the

Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is involved in this document which is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111(d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every 4 years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE IRON AND STEEL FOUNDRY INDUSTRY PROCESSES AND POLLUTANT EMISSIONS

3.1 GENERAL

Iron and steel foundries, as considered in this document, can be defined as those which produce gray, white, ductile, or malleable iron and steel castings. Cast iron and steels are both solid solutions of iron, carbon, and various alloying materials. Although there are many types of each, the iron and steel families can be distinguished by their carbon content. Cast irons typically contain 2 percent carbon or greater; cast steels usually contain less than 2 percent carbon.[1] Chemical specifications of various cast irons are presented in Table 3-1.

The major industry users of castings [by Standard Industrial Classification (SIC)] are summarized in Table 3-2. Iron castings are used in almost all types of equipment, including motor vehicles, farm machinery, construction machinery, petroleum industry equipment, electrical motors, and iron and steel industry equipment. Steel castings are classified on the basis of their composition and heat treatment, which determine their end use. Steel casting classifications include carbon, low alloy, general purpose structural, heat resistant, corrosion resistant, and wear resistant. They are used, for example, in motor vehicles, railroad equipment, construction machinery, aircraft, agricultural equipment, ore refining machinery, and chemical manufacturing equipment.

In 1978 there were 4,438 foundries of all types in the United States, including the following:[2]

Number of Foundries	Metal Cast
1,400	Gray Iron
590	Ductile Iron
107	Malleable Iron
631	Steel

TABLE 3-1. RANGE OF COMPOSITIONS FOR TYPICAL CAST IRONS[1]

Element	Gray iron, %[a]	White iron, %[a]	Malleable iron (cast white), %[a]	Ductile iron, %[a]
Carbon	2.5 - 4.0	1.8 - 3.6	2.00 - 2.60	3.0 - 4.0
Silicon	1.0 - 3.0	0.5 - 1.9	1.10 - 1.60	1.8 - 2.8
Manganese	0.25 - 1.0	0.25 - 0.80	0.20 - 1.00	0.00 - 1.00
Sulfur	0.02 - 0.25	0.06 - 0.20	0.04 - 0.18	0.03 maximum
Phosphorus	0.05 - 1.0	0.06 - 0.18	0.18 maximum	0.10 maximum

[a] Percent by weight.

TABLE 3-2. END-USE DISTRIBUTION OF CASTINGS[2]

	SIC code[a]	Industry[b]
A. Iron castings	3714	Motor vehicle parts and accessories
	3523	Farm machinery and equipment
	3519	Internal combustion engines, nec.[c]
	3494	Valves and pipe fittings
	3561,3	Pumps and compressors
	3585	Refrigeration and heating equipment
	3531	Construction machinery
	3566	Power transmission equipment
	3621	Motors and generators
	3541	Machine tools, metal cutting types
B. Steel castings	3743	Railroad equipment
	3531	Construction machinery
	3714	Motor vehicle parts and accessories
	3494	Valves and pipe fittings
	3495	Wire springs
	3559	Special industry machinery, nec.
	3561,3	Pumps and compressors
	3728	Aircraft equipment, nec.
	3711	Motor vehicles and car bodies
	3533	Oil field machinery

[a] SIC = Standard Industrial Classification.
[b] Ranked by production (highest 10 listed).
[c] nec. = not elsewhere classified.

Some of the above foundries may cast other metals in addition to iron or steel. In 1978 there were 1,074 electric arc furnaces (EAF) in operation in 440 foundries of all types (e.g., iron, steel, nonferrous) in the United States. Other types of melting equipment may be used in addition to the electric arc furnace at a foundry, and a foundry may have more than one electric arc furnace.

Limited data on iron foundries indicate that there were 371 electric arc furnaces in use at gray and ductile iron foundries in 1973.[3] Table 3-3 presents a summary of foundry data by State which indicates 396 electric arc furnaces were operational in steel foundries in 1977-78.[4] Table 3-3 also contains data on the total number of foundries, number of EAF's, and employment at steel foundries with EAF's. The employment figures are estimates and include all personnel working at the company or foundry.

Larger furnaces, 9 to 14 megagrams per hour (Mg/h) [10 to 15 tons per hour (tons/h)], are usually located in integrated machine-producing plants; very few furnaces produce more than 14 Mg/h (15 tons/h). Smaller furnaces, down to a fraction of a ton per hour, are located in plants that produce a limited variety of products or small quantities of speciality iron castings. Small furnaces are operated periodically; large furnaces usually are operated in two shifts.

Almost all facilities that produce steel castings are jobbing (i.e., produce castings for sale to, or use by, other facilities) foundries. Very few arc furnaces that melt steel are part of integrated plants. Smaller furnace operations are located in plants that produce a limited variety of products or small quantitites of special steel castings. Small steel foundries operate their arc furnaces periodically; larger foundries usually are operated in two shifts.

The iron and steel foundry industry shipped 16.83 million Mg (18.55 million tons) of castings during 1978. Shipments in 1979 were projected to reach 17.7 million Mg (19.5 million tons).[5] It should be noted that total plant capacity will exceed total shipments by up to 40 percent as a result of the production of foundry returns and defective castings. A summary of the production, employment, shipment value, and export and import values are presented in Table 3-4. Production for 1979 was projected to increase 5.0 percent over 1978, and production for 1980

Some of the above foundries may cast other metals in addition to iron or steel. In 1978 there were 1,074 electric arc furnaces (EAF) in operation in 440 foundries of all types (e.g., iron, steel, nonferrous) in the United States. Other types of melting equipment may be used in addition to the electric arc furnace at a foundry, and a foundry may have more than one electric arc furnace.

Limited data on iron foundries indicate that there were 371 electric arc furnaces in use at gray and ductile iron foundries in 1973.[3] Table 3-3 presents a summary of foundry data by State which indicates 396 electric arc furnaces were operational in steel foundries in 1977-78.[4] Table 3-3 also contains data on the total number of foundries, number of EAF's, and employment at steel foundries with EAF's. The employment figures are estimates and include all personnel working at the company or foundry.

Larger furnaces, 9 to 14 megagrams per hour (Mg/h) [10 to 15 tons per hour (tons/h)], are usually located in integrated machine-producing plants; very few furnaces produce more than 14 Mg/h (15 tons/h). Smaller furnaces, down to a fraction of a ton per hour, are located in plants that produce a limited variety of products or small quantities of speciality iron castings. Small furnaces are operated periodically; large furnaces usually are operated in two shifts.

Almost all facilities that produce steel castings are jobbing (i.e., produce castings for sale to, or use by, other facilities) foundries. Very few arc furnaces that melt steel are part of integrated plants. Smaller furnace operations are located in plants that produce a limited variety of products or small quantitites of special steel castings. Small steel foundries operate their arc furnaces periodically; larger foundries usually are operated in two shifts.

The iron and steel foundry industry shipped 16.83 million Mg (18.55 million tons) of castings during 1978. Shipments in 1979 were projected to reach 17.7 million Mg (19.5 million tons).[5] It should be noted that total plant capacity will exceed total shipments by up to 40 percent as a result of the production of foundry returns and defective castings. A summary of the production, employment, shipment value, and export and import values are presented in Table 3-4. Production for 1979 was projected to increase 5.0 percent over 1978, and production for 1980

TABLE 3-3. SUMMARY OF FOUNDRIES BY STATE[2,4]

State	Total No. of foundries, all types (1979)	Total number of foundries casting				Total No. of EAF's all foundry types[2] (1979)	Total No. of EAF's steel foundries[4] (1977-78)	Steel foundry EAF employment[4] (1977-78)
		Gray iron[2] (1979)	Ductile iron[2] (1979)	Malleable iron[2] (1979)	Steel[4] (1977-78)			
Alabama	94	53	25	1	8	37	13	1,790
Alaska	1	--	1	--	--	--	--	--
Arizona	21	4	2	2	3	12	9	680
Arkansas	44	11	4	--	1	5	2	200
California	431	80	35	3	15	54	26	3,690
Colorado	48	15	6	--	2	7	3	640
Connecticut	97	19	8	5	3	17	4	1,680
Delaware	6	1	--	--	2	3	3	708
District of Columbia	3	1	--	1	--	--	--	--
Florida	56	8	4	--	3	4	4	345
Georgia	47	18	9	8	3	7	6	360
Hawaii	2	1	--	--	--	2	--	--
Idaho	6	4	1	--	--	1	--	--
Illinois	319	75	34	6	15	55	31	7,000
Indiana	194	72	23	3	10	30	16	5,085
Iowa	74	31	11	1	2	20	4	940
Kansas	55	24	11	--	2	7	4	1,375
Kentucky	28	13	1	1	--	1	--	--
Louisiana	24	9	1	--	4	30	10	1,285
Maine	13	6	1	--	--	--	--	--
Maryland	24	8	5	--	--	4	--	--
Massachusetts	137	41	16	2	2	15	3	315

TABLE 3-3. SUMMARY OF FOUNDRIES BY STATE[2,4]
(continued)

State	Total No. of foundries, all types (1979)	Total number of foundries casting				Total No. of EAF's all foundry types[2] (1979)	Total No. of EAF's steel foundries[4] (1977-78)	Steel foundry EAF employment[4] (1977-78)
		Gray iron[2] (1979)	Ductile iron[2] (1979)	Malleable iron[2] (1979)	Steel[4] (1977-78)			
Michigan	351	111	52	15	11	134	24	3,100
Minnesota	91	34	8	1	2	10	3	800
Mississippi	14	7	--	1	1	2	1	160
Missouri	116	29	8	2	11	26	15	2,870
Montana	3	2	1	1	--	--	--	--
Nebraska	20	6	--	--	1	4	1	170
Nevada	4	2	--	--	1	1	1	25
New Hampshire	31	7	1	1	1	14	2	155
New Jersey	130	22	14	1	3	24	4	695
New Mexico	14	1	--	--	--	--	--	--
New York	265	59	23	7	9	52	16	3,915
North Carolina	52	23	7	--	--	2	--	--
North Dakota	1	--	--	--	--	--	--	--
Ohio	456	154	70	14	22	92	35	7,265
Oklahoma	46	22	18	--	2	5	3	670
Oregon	54	12	7	--	5	19	12	1,395
Pennsylvania	375	144	66	20	27	97	54	12,850
Rhode Island	49	5	1	1	--	--	--	--
South Carolina	28	13	5	--	--	6	--	--
South Dakota	3	2	1	--	--	--	--	--
Tennessee	80	35	11	1	2	3	3	465
Texas	183	62	34	5	13	56	22	2,995

TABLE 3-3. SUMMARY OF FOUNDRIES BY STATE[2,4] (concluded)

State	Total No. of foundries, all types (1979)	Total number of foundries casting: Gray iron[2] (1979)	Ductile iron[2] (1979)	Malleable iron[2] (1979)	Steel[4] (1977-78)	Total No. of EAF's all foundry types[2] (1979)	Total No. of EAF's steel foundries[4] (1977-78)	Steel foundry EAF employment[4] (1977-78)
Utah	16	11	5	1	1	4	2	230
Vermont	4	4	1	--	--	1	--	--
Virginia	48	28	7	--	1	8	3	400
Washington	56	18	9	3	11	24	21	1,740
West Virginia	26	10	5	1	1	4	1	120
Wisconsin	197	81	38	7	15	70	35	6,210
Wyoming	2	1	1	--	--	2	--	--

TABLE 3-4. FOUNDRY INDUSTRY DATA AND PROJECTIONS[5,6]

Iron and steel foundry data	1976	1977	1978	1979[a]	1980[a]
Quantity shipped, total (10^3 Mg)	15,265	15,950	16,828	17,682	18,300
Gray iron (10^3 Mg)	10,827	11,182	11,702	12,166	--
Ductile iron (10^3 Mg)	2,035	2,456	2,722	2,994	--
Malleable iron (10^3 Mg)	767	753	771	798	--
Steel (10^3 Mg)	1,636	1,559	1,633	1,724	--
Quantity shipped, total (10^3 tons)	16,827	17,582	18,550	19,491	20,173
Gray iron (10^3 tons)	11,935	12,326	12,900	13,441	--
Ductile iron (10^3 tons)	2,243	2,707	3,000	3,300	--
Malleable iron (10^3 tons)	846	830	850	880	--
Steel (10^3 tons)	1,803	1,719	1,800	1,900	--
Value of shipments ($ million)	10,072	11,751	14,578	16,946	18,302
Average value ($/ton)	598.6	668.4	785.9	869.4	907.3
Total employment (10^3)	216	220	231	242	250
Production workers (10^3)	179	180	189	198	205
Value of shipments ($ million)	9,787	11,418	14,165	16,438	--
Value of exports ($ million)	283	291	302	315	--
Value of imports ($ million)	79	110	132	162	--

[a] Projected data.

is projected to increase 3.5 percent over 1979. Additional data for the period 1973 through 1983 are given in Section 8.1.

3.2 IRON AND STEEL FOUNDRY PROCESSES AND EMISSIONS

3.2.1 General Operations

All iron and steel foundries perform four basic operations:

1. storage and handling of raw materials;
2. melting of the raw materials;
3. transfer of the hot molten metal into molds; and
4. preparation of the molds to hold the molten metal.

Other processes present in most, but not all, foundries include:

1. sand preparation and handling;
2. mold cooling and shakeout;
3. casting cleaning, heat treating, and finishing;
4. coremaking; and
5. pattern making.

A simplified, schematic flow diagram encompassing most of these processes for a typical iron or steel foundry is presented in Figure 3-1. Each foundry process generates certain quantitites of gases, smoke, fume, and/or particulate emissions.

Castings are produced in a foundry by injecting or pouring molten metal into cavities of a mold made of sand, metal, or ceramic material. When the metal has solidified, the molds are separated and the castings removed from the mold flasks on a casting shakeout unit with subsequent abrasive (shotblasting) cleaning, grinding, and heat treating, if necessary. The castings are then inspected and shipped to another industry for machining and/or assembly into a final product.

The raw materials that may be used for iron or steel castings include: metallics, carbon and flux, fuel, refractories (furnace lining), and molding materials, as indicated in Table 3-5. All types of furnaces which produce iron or steel may use similar raw materials. A foundry may operate a "scrap receiving station" where the scrap is stored and classified according to size, chemistry, and/or density. Oil content may be adjusted in a "cleaning station," where part of the oil can be removed by centrifuging or heating. Foundries with induction furnaces often feature another station, the "preheater," to remove water and oil to preclude the

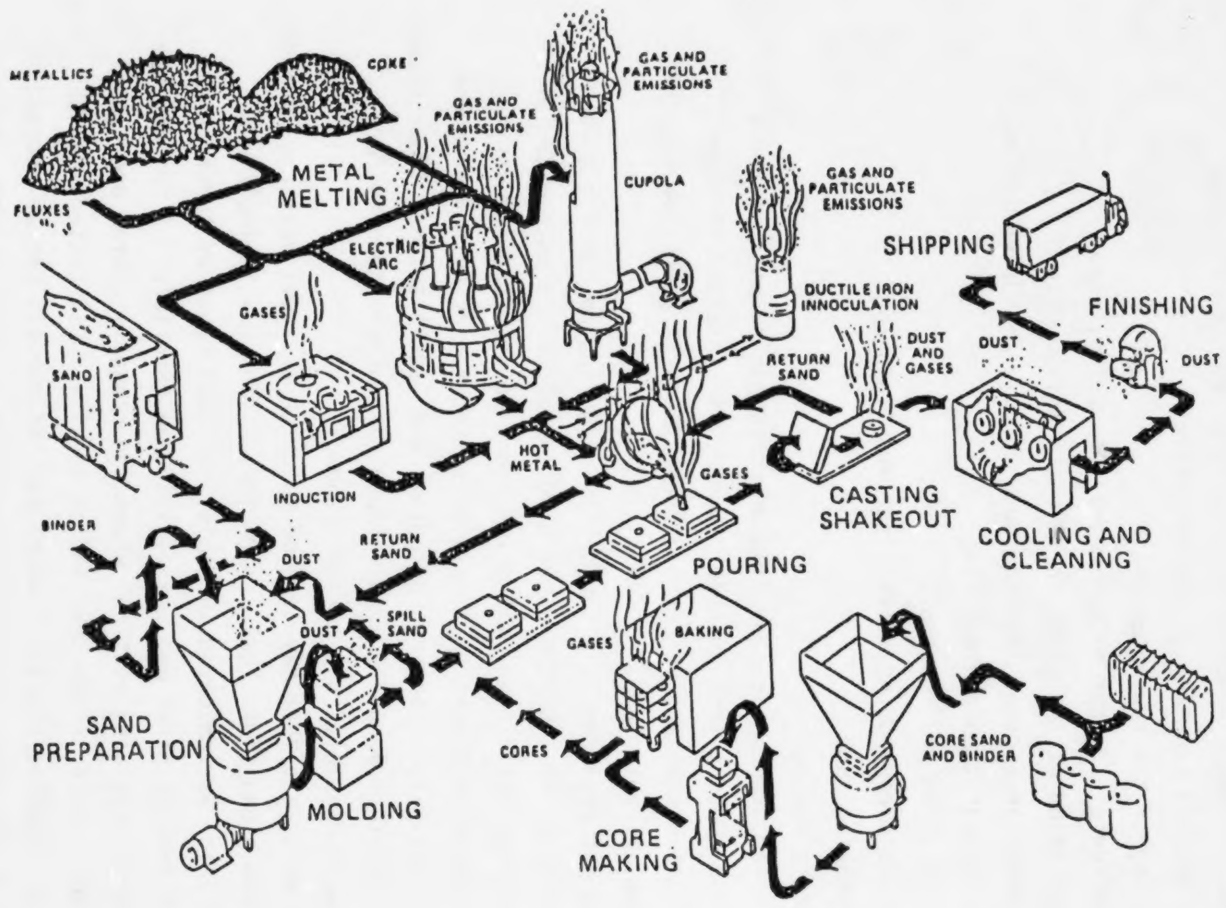

METALLICS
COKE
FLUXES
METAL MELTING
GAS AND PARTICULATE EMISSIONS
GAS AND PARTICULATE EMISSIONS
CUPOLA
GAS AND PARTICULATE EMISSIONS
SHIPPING
ELECTRIC ARC
GASES
DUCTILE IRON INNOCULATION
FINISHING
SAND
DUST AND GASES
DUST
DUST
RETURN SAND
HOT METAL
INDUCTION
GASES
CASTING SHAKEOUT
COOLING AND CLEANING
BINDER
RETURN SAND
DUST
POURING
DUST
SPILL SAND
GASES
BAKING
SAND PREPARATION
CORES
CORE SAND AND BINDER
MOLDING
CORE MAKING

Figure 3-1. Iron and steel foundry process flow and emission sources.

TABLE 3-5. RAW MATERIALS USED FOR IRON AND STEEL PRODUCTION[7]

Metallics

- Pig iron
- Cast iron scrap
- Steel scrap
- Turnings and borings (loose or briquettes)
- Foundry returns
- Ferroalloys
- Innoculants, including magnesium alloys

Carbon additive

- Graphite
- Electrode scrap
- Calcined gilsonite
- Anthracite
- Coke breeze
- Silicon carbide

Fluxes

- Carbonates (limestone, dolomite, soda ash)
- Fluorides (fluorspar)
- Carbides (calcium carbide)

Fuel

- Coke
- Electricity
- Other fossil fuel

Refractories

- Firebrick: alumina, silica, magnesite, graphite

Mold preparation

- Sand
- Additives, binders

possibility of an explosion hazard. Electric arc furnaces could have preheaters also, but this is seldom done because they are not as susceptible to explosion. Moderate preheating of EAF charges may be done by holding the charge over the furnace.

The charges are made up in proper sequence at the "charge makeup stations." The bucket receiving the charge is either placed on a weighing platform or a scale is attached to the crane used to lift the scrap into the bucket. In this way, the bucket is charged with proper quantities of materials and additives. The charge is transferred to an electric furnace and dropped into the furnace by opening the bottom of the bucket. Cupolas, on the other hand, are charged via a skip hoist with special buckets or by other methods. The charge in a furnace is heated until it reaches a certain temperature and the proper chemistry of the melt has been verified. The molten metal can either be poured out of the furnace into various sized teeming ladles and then into the molds or transferred to holding furnaces for later use.

About 70 percent of all iron is produced in the cupola with lesser amounts produced in electric arc and induction furnaces. Steel foundries rely almost exclusively on electric arc or induction furnaces. Other types of furnaces may also be used in either foundry type, but to a minor extent. Since the electric arc furnace is the designated affected facility under investigation in this document, it is the only process that is discussed in the following sections.

3.2.2 Electric Arc Furnace Operations and Emissions

The direct electric arc furnace is a refractory-lined, cylindrical vessel made of heavy, welded steel plates and having a bowl-shaped hearth and a dome-shaped roof. Three graphite or carbon electrodes are mounted on a superstructure above the furnace and can be lowered and raised through holes in the furnace roof. Water-cooled glands are provided at the holes to cool the electrodes. With the electrodes raised, the furnace roof can be swung aside to permit the charge materials to be dropped into the furnace (top charged). Additional alloying agents, as required, are added through the side or slag door of the furnace. Top charging of materials is the most economical method because a furnace can be charged to the brim within a few minutes. (Some smaller or older furnaces are charged through side doors.) The furnace is usually mounted on curved rocker trunnions. Hydraulic cylinders or electromechanical means are used for tilting the furnace.

Foundries using electric arc furnaces as melters may consist of the electric furnace itself, scrap storage area, scrap weighing stations, molten metal and slag ladles, and hot metal holding furnaces. Holding furnaces are usually of the induction type; arc furnaces are rarely used for this purpose. Heavy duty cranes are used to transfer the materials from one point to another within the shop. The scrap is charged by a drop bottom bucket carried by the crane.

The production of iron or steel in an electric arc furnace is a batch process where cycles or "heats" range from 60 minutes to several hours depending on the size of the charge, the power input to the furnace, and the quality of the metal melted. Each cycle normally consists of charging, melting (melt down of the charge), refining, and tapping. An overall diagram outlining the emissions from electric arc furnace operations is presented in Figure 3-2.

There are circumstances that may delay the operation of an electric arc furnace. "Sheds" (the cutting off of the power to the electrodes) occur frequently and might not be considered unusual operating delays. Delays that might be considered unusual, however, are: lack of room in the holding furnaces or on the molding floor, thus delaying the tapping of the electric furnace; failure of the crane to arrive on time; failure of the electrode lifting mechanism; improper arcing of electrodes; loss of plant power; and an inoperative furnace roof which cannot be opened or closed.

Electric arc furnaces for iron foundries and steel foundries are very similar.[7] At foundries which pour both iron and steel, both metals can be produced in the same furnace. Steel production at times requires an oxygen lance to dislodge scrap which adheres to furnace walls, to adjust the furnace chemistry, or to increase the melt rate. Steel furnaces may also be backcharged with additional scrap of low density during the melt period. Oxygen lancing and backcharging temporarily increase particulate emission rates from steel furnaces. Iron production does not ordinarily require the use of these operations, although backcharging may

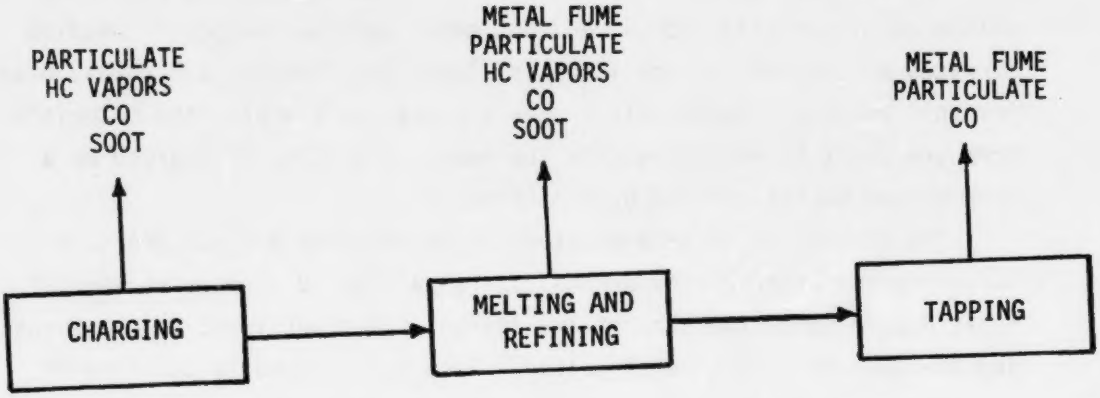

PARTICULATE
HC VAPORS
CO
SOOT
METAL FUME
PARTICULATE
HC VAPORS
CO
SOOT
METAL FUME
PARTICULATE
CO
CHARGING
MELTING AND REFINING
TAPPING

Figure 3-2. Emissions from electric-arc furnace operation.

be performed. The chemical composition of the emissions from iron and steel production is similar, although there is some variation in the relative amounts of the metal oxides emitted.

There are some differences in the design and operation of furnaces used in iron and steel foundries. While the refractory lining for furnaces used in the production of iron is usually acidic, furnaces for steel castings can have either basic or acidic refractory, depending on the desired steel composition and the availability of charging materials. Acid-refractory-lined furnaces are used for the production of plain and alloyed steels. Acid furnaces have silica brick walls and supporting brickwork, while the hearth is covered with quartzite. Basic furnaces are used also for melting plain and alloyed steels. In basic furnaces, the bottom is made of two or three layers of magnesite brick over which a layer of magnesite or dolomite 150 to 200 mm (5.9 to 7.9 in.) thick is rammed into place.

3.2.2.1 Charging. Iron or steel scrap is usually loaded into the charge bucket with an electromagnet suspended from a crane. The bucket stands on a scale or a scale car in the scrap makeup area. The weight of the materials in the bucket is displayed electronically or on a dial that is clearly visible to the crane operator.

The charge to an electric arc furnace producing iron consists of steel scrap, foundry returns, and additives such as carbon raiser, manganese, and silicon. Foundry returns include sprues, gates, runners, risers, defective castings, and borings from machining operations. Carbon raiser is carbon in the form of graphite or coke breeze and is used to increase the carbon content of iron. Loose charge, such as turnings and borings, in excess of 20 percent is normally avoided because it increases the power consumption, electrode consumption, and melting time. The material charged to an electric arc furnace in a gray iron foundry typically has the following composition:[8-10]

1. 50 to 60 percent iron (approximately 80 percent foundry returns and 20 percent cast iron turnings or borings);
2. 37 to 45 percent steel (approximately 70 to 100 percent steel pieces and less than 30 percent steel turnings);

3. 0.5 to 1.1 percent silicon (usually as ferro silicon);
4. 1.3 to 1.7 percent carbon raiser; and
5. 0.2 percent ferro manganese (FeMn).

The charge for steel production differs from the above in that the foundry returns are mostly steel and little carbon raiser is added. The carbon raiser is added in very small amounts and may be in the form of pig iron. The carbon level for steel production is 83 to 87 percent lower than the level for iron production.[7] The charge to a basic furnace can consist of 20 to 50 percent foundry returns and 50 to 80 percent steel scrap and additives. Basic furnace charges may contain various kinds of materials with high levels of phosphorus and sulfur. The charge to an acid furnace must contain very small amounts of sulfur and phosphorus because these elements cannot be removed by acid-lined furnaces.

The charge is introduced into the furnace by the charging bucket. This manner of charging the furnace produces emissions which are not controlled in most of the existing plants. Emissions result from: (1) vaporization and partial combustion of the oil introduced with any scrap, borings, turnings, and chips which are contained in the charge; (2) oxidation of organic matter which may adhere to the scrap; and (3) liberation of sand particles which are introduced into the furnace on the surface of casting returns. High oil content is characteristic of the least expensive scrap, e.g., swarf (turnings, chips, and borings) from machine operations. Charging emissions are essentially made up of particulate matter, carbon monoxide, hydrocarbon vapors, and soot.

Proper size selection and distribution of the scrap during charging (and backcharging) is important. During its transfer into the furnace, the scrap should be distributed in a way that does not damage the furnace refractory. In the case of scrap pieces remaining above the parting line (bezel ring), the pieces must be relocated so that the roof will close. This relocation may be done using the charge bucket, or some other large mass of metal suspended from the crane, to tamp the charge into the furnace. It may also be performed by the use of an oxygen lance. The oxygen burns off the connection to the wall or cuts the pieces apart if they are off the walls. These operations are carried out with the slag door open. Charging of additives, such as lime and coke, is performed through the slag door or when the roof is swung. Both operations result in emissions into the furnace bay area. After charging is completed, the roof is rotated back into position and lowered onto the furnace. A very small gap may remain between the roof and the bezel ring of the furnace.

3.2.2.2 Melting and Refining. Arc furnace transformers are designed for connection to a high voltage supply. The main items of electrical equipment are a circuit breaker, a step-down transformer, and, for small transformers, a tapped reactor to give arc stability and to dampen current surges. The transformer is provided with tap changing equipment to give a range of secondary voltages to suit the melting, superheating, and refining conditions in the furnace. The electrodes are raised or lowered by electromechanical or electrohydraulic devices. At a given transformer voltage, lowering the electrodes shortens the arc and increases the current and power input and vice versa. Electrode movement is accomplished by automatic control in normal operation.

The step-down transformer decreases voltage from 2.3-35 kilovolts to 80-375 volts. The voltage varies with the primary line voltage available and the size of the furnace transformer. The transformer may have from 3 to 33 taps on the high voltage side for better control of electric supply and heat conditions of the furnace. The power is first passed through the high voltage transformer, then through a selected tap among the number of taps off of the primary coil of the transformer. The voltage levels applied to the furnace are governed by the size of the furnace, phase of the furnace cycle, metal temperature, and other factors.

When the furnace is ready for the melting cycle, the electrodes are positioned manually just above the scrap charge. The electrodes then may be energized and put on automatic operation. As the electrodes lower, one will reach the scrap first. With some controls, this electrode will rise instantly at the slightest electrical contact with the scrap to break the contact as though anticipating the current surge which occurs when the second electrode gets close to the scrap. In a few seconds, the phases should be balanced and the furnace is "in business." If short arcs occur, the electrodes may not melt enough metal to avoid damage to the refractory on the bottom of the furnace. With long arcs, the electrodes will melt out larger holes in the scrap charge. Heat radiated from the long arcs and reflected from the pool surface goes up into the cold scrap surrounding the electrodes. Thus the charge is preheated and melted down faster into the molten bath.

When the charge is melted down, the long arcs, if not shortened, would overheat the sidewall and roof refractories before the molten metal got hot. Oxygen is now used almost universally (instead of iron ore or mill scale) for "boiling" a heat of steel to flush out gases, mainly hydrogen. Oxygen may increase the metal temperature without the arcs because the carbon boil reaction is exothermic. If further arcing is needed to increase the metal temperature but the refractories are already too hot, then the arcs may be shortened by simply increasing the arc current (if the circuits can handle a higher current) or by changing to a lower voltage tap. When the metal is up to temperature, further reductions in the arc length may be made by switching to still lower taps as the practice requires.

Melting is accomplished by the heat supplied by direct radiation from the arcs formed between the electrodes of the furnace and the metallic charge, by direct radiation from the furnace lining, and by the resistance of the metal between the arc paths. Melting begins by striking an arc between the electrodes often using the highest voltage tap in the transformer. As the electrodes bore into the solid charge, much fume and noise result. After the charge is melted, the molten bath surface becomes completely flat (i.e., with no incompletely melted pieces floating in the molten material). The bath temperature is about 1370°C (2500°F) but may vary considerably, depending on the type of metal melted. During the next period, the furnace is fed from another tap while the bath is superheated. In some foundries, a sample is then taken for chemical analysis prior to pouring.

When the desired temperature is reached, the molten bath is usually skimmed to remove the slag. Slagging, which is usually performed with the power off, is normally carried out once per heat. The furnace is tilted 10 to 15 degrees from the vertical. Sand may be thrown on the threshold of the slagging door to prevent the slag from sticking; the slag is then manually withdrawn with slag rakes into a slag pit, bucket, or ladle.

After slagging is complete, the power is restored at a lower tap for 15 to 30 minutes to superheat and refine the melt. During this time, the furnace chemistry and bath temperature are checked and adjusted if necessary. These two operations last only a few minutes. As soon as the proper chemistry and metallurgy are reached, the furnace is prepared for tapping. In some cases, refining may be performed in the ladle or in a holding furnace.

Steel melting in acid or basic EAF's can be carried out either with oxidation (oxidizing the impurities with iron ore or oxygen) or without oxidation (fusion of steel scrap).[11] The choice of a method depends on the type of steel produced, the charge materials available, and, in particular, the amounts of sulfur and phosphorus in the charge.

Oxidation is not used if the metal ingredients of the charge are close to those desired because oxidation would remove some of the valuable alloying elements. In such cases, only a reducing slag is used, both in melting and refining. Usually, this process (single refining or single slag practice) is employed to smelt alloy wastes to alloy steels. During melting with oxidation, also known as double slag working, the charge is melted under an oxidizing (black) slag. Then this slag is removed and a reducing or white slag is formed under which refinement is completed. This method may be used to remove gases (hydrogen, nitrogen) from the plain carbon steels.

The oxidizing slag is formed by the addition of lime and iron ore (or oxygen) to the furnace before the charge is molten. Oxygen is used more frequently than iron ore. Oxidizing treatment under a basic slag removes most of the phosphorus and carbon from the melt, lowering their concentrations to the desired levels. The purposes of reducing slag are: (1) to deoxidize the metal; (2) to eliminate the sulfur; and (3) to finish the steel to the specified composition. The reducing slag is formed from lime, fluorspar, and coke breeze. The deoxidation of the metal results from the reaction of dissolved oxygen in the metallic solution with carbon and ferrosilicon or aluminum, both very effective deoxidizing additives. Nonmetallic inclusions, such as sulfur, are removed from the metal into the slag in the form of calcium sulfide.

Steel casting furnaces are sometimes backcharged (i.e., a second charge is added to the furnace) as soon as sufficient volume is available in the furnace after the first charge. Normally, the furnace at an iron foundry is charged only once with the full charge, and backcharging is usually not practiced. If the carbon level is too high, however, some steel can be added through the slag door--preferably clean, dry pieces that will drop to the bottom of the molten iron bath.

Oxygen lancing in steel furnaces is used mainly for adjustment of the chemistry of the steel, for speeding up of the melting process, and for superheating of the bath. Oxygen lancing results in increased bath and gas temperatures, gas evolution, and generation of particulates. Oxygen lancing can be carried out with moderate rates of oxygen addition, thereby avoiding excessive generation of high temperatures, gas evolution, and particulates. However, extended periods of oxygen lancing can increase refractory wear and oxidation of the bath and decrease the production rate.

Other occurrences during melting that may result in emissions are the sudden collapse of pieces of the charge and the necessity to push pieces under the electrodes. (Pushing pieces under the electrodes is performed with the power off.) In such instances, the door (usually the slag door) must be opened, which results in emissions escaping through the electrode holes. Emissions of this kind are highly visible within the shop and may reach the roof openings and escape into the atmosphere. These emissions are more pronounced in furnaces with direct furnace evacuation than in furnaces with side draft hood evacuation.

During the production of some alloys, as already mentioned, a second slagging operation may take place, depending on the melting practice utilized. The addition of reducing slag must be carried out with a minimum amount of air since induction of air into the furnace will oxidize the reducing slag, rendering it ineffective. An inflow of air will also cool the slag and bath, slowing the chemical reactions between the two substances. If direct shell evacuation is used, it may be necessary to adjust the air flow. Some melters stop the flow of air completely by shutting down the fan; others reduce the flow of air to a much lower volume.[12,13] These techniques have two disadvantages. Turning off the fan or operating the fan at a lower volume can result in the escape of emissions through the electrode holes into the furnace bay area. Second, the industry advances a theory that the configuration of the furnace roof which is required to accommodate the direct shell evacuation system may produce a cold spot in the molten steel when the flow of air is reduced.[14] It is alleged that the absence of refractory where the discharge duct enters the roof acts as a black body surface which absorbs radiant heat from the melt, thus creating the cold spot.

As another method of adjusting the chemistry of the molten metal, some foundries practice reladling (refurnacing). This procedure involves tapping one-third to one-half of the molten metal into the ladle and then pouring this tap back into the furnace. The molten metal is thus forced to mix with the slag, enhancing sulfur removal. Reladling may also be performed to preheat the ladle.

During melting operations (meltdown, slagging, and refining), emissions consist of: (1) particulates as metallic and nonmetallic oxides generated from vaporization of iron and transformation of mineral additives; (2) carbon monoxide from combustion of the graphite electrodes, carbon raisers and carbon in the metal; and (3) hydrocarbons from vaporization and partial combustion of oil remaining in the charge.

During melting, emissions escape from the furnace through electrode annuli (holes), the slag doors, the roof ring (the joint between the furnace shell and roof), and sometimes the tap spout.[7] Proper maintenance of the furnace will minimize the escape of emissions through these openings and improve the efficiency of emission evacuation systems used for control of melting emissions.

Backcharging produces a violent eruption of particulate emissions with a strong thermal driving force. The amount of pollutants generated during this phase of the operation is probably higher than during either the first charge or during treatment of the molten bath in the transfer ladle.[15]

3.2.2.3 Tapping. When the proper chemistry, temperature, and metallurgy of the melt are reached, the melt is tapped. The tapping temperatures are determined by the type of alloy being cast, the section thickness and size of the castings being poured, as well as other pertinent factors which affect the castability of the parts being produced. These temperatures may be on the order of 1500°-1600°C (2730°-2910°F) for iron and 1600°-1815°C (2910°-3300°F) for steel, depending on the type. The electrodes are raised, the furnace is tilted by as much as 45 degrees, and the refined metal flows into a ladle. The melt is then poured into molds or temporarily stored in the molten State in holding furnaces. During tapping, sparks and emissions consisting of molten iron or steel fume are generated and become a source of ferrous oxide particulate emissions.[8] Tapping of iron generally produces considerably fewer emissions than the charging of the furnace. However, when alloys are added to the ladle, tapping emissions are somewhat greater than charging emissions and considerably greater than emissions from tapping of unalloyed iron. The higher emission rates from the tapping of steel furnaces are due to the higher temperature required for steel production and the fact that generally more alloys are added to steel than to iron. Tapping emissions are often unconfined and escape as fugitive emissions through foundry roof vents.[7]

3.2.2.4 Material Balances. The metal yield of an electric arc furnace is rather high. From a typical charge in the gray iron foundry industry, 94 to 98 percent gray iron is produced. In addition, 0.65 to 0.75 percent of the iron in the charge escapes as dust, and the remainder is lost in the slag. In steel foundries, a typical charge may produce 92 to 93 percent molten steel. Similarly, 0.65 to 0.75 percent of the iron escapes as dust, and 6 to 7 percent is lost in the slag. Basic furnaces are generally less efficient than acid furnaces because several slags may sometimes be required.

Electrode consumption is 3.6 to 4.5 kilograms per megagram (kg/Mg) [7.2 to 8.9 pounds per ton (lb/ton)] of metal melted for acid furnaces with a slightly higher consumption for basic furnaces. Many factors contribute to electrode consumption; a systematic study of the complex interactions involved has not been published. Electrode consumption is a source of hydrocarbon, carbon monoxide, and carbon dioxide emissions.

3.2.2.5 Energy Considerations. Only electrical energy is used in electric arc furnace operations, unless some preheating of the charge or ladle is carried out. The largest portion of energy is consumed for melting and refining of the charge, but some energy is used for the operation of pumps, cranes, building evacuation equipment, and air pollution control equipment.

Between 1,620 and 2,475 megajoules per megagram (MJ/Mg) [410 and 625 kilowatt-hours per ton (kWh/ton)] of energy are consumed by the furnace, depending on the quantity of borings added to the charge, the type of operation (acidic or basic), the final temperature, and the quality of the metal produced. The lower figure corresponds to a quantity of borings representing about 10 percent of the charge makeup; the higher figure refers to a charge with well over 50 percent uncompressed borings.

The power rating (kilovolt-ampere, kVA) increases with the size of furnace. The refractory wear becomes excessive with high power levels. This is proven in practice and confirmed by theories developed by W. E. Schwabe (i.e., the so-called "refractory wear index").[16]

Energy can also be expended in a pretreating process, such as centrifuging out excessive oil from borings, or by drying and/or preheating the scrap. It is desirable to have as little oil in the scrap as possible. Borings are a special problem because their large surface can contain a significant amount of oil. Borings can be centrifuged to reduce their oil content to about 2 percent by weight.

If the charge is preheated to drive out superficial water, it is heated to 93°C (200°F). (Energy spent for this purpose does not improve the operating efficiency of the furnace.) If the drying process is carried out at 202° to 232°C (395° to 450°F), not only will the water be driven out but also some oil (which adheres to the scrap) will be volatilized and partially combusted. Scrap preheated to the above temperature saves about 140 MJ/Mg (35 kWh/ton) of metal produced. With a preheat of 650°C (1200°F), known as "full preheating," energy consumption is theoretically reduced by about 495 MJ/Mg (125 kWh/ton).[17] Preheating is primarily used on charges for induction furnaces and is seldom used on charges for EAF's. The degree of preheat is a function of several factors, including the type and condition of the scrap.

Full preheating burns off the oil and some other contaminants so that substantially fewer emissions are generated during charging and less slag is formed, which helps protect the lining of the furnace. Preheating, therefore, results not only in energy savings but also in air pollution reduction at the furnace plus extended life of the furnace lining. The preheater itself is a source of pollution; however, the gas volume from the preheater is less than from the charging emissions from an open furnace.

3.2.2.6 Emissions. As noted above, the equipment and processes involved in each of the operations diagrammed in Figure 3-1 are capable of producing air pollutants in the form of fumes, gases, and particulates. The major emissions are fine particles (ferrous and nonferrous oxides) from the melting furnace(s). Coarse particles are generated during grinding operations, shaking, blasting, and sand reclamation. Polynuclear aromatic hydrocarbons (PNA's) may be evolved during preheating of scrap and charging of scrap to the furnace when the scrap is coated with organics.

Charging and tapping emissions from electric arc furnaces have not been extensively quantified because these emissions are usually unconfined, and they are difficult to segregate from other foundry emission sources. Extrapolation of limited emission test data from charging and tapping at steelmaking EAF's indicates that charging and tapping at iron and steel foundries may account for up to 10 percent of the total furnace emissions, when alloying is conducted in the ladle.[18-20] When there are no alloys added to the ladle, as is sometimes the case with iron production, then charging and tapping are estimated to produce 5 percent of total furnace emissions.

The rate of emissions from iron EAF's during melting and refining can vary depending on furnace size, charge composition, melting rate, tapping temperature, and, primarily, the quality and cleanliness of the scrap. The quality of scrap charged has a strong effect on emissions because the inclusion of large quantities of lower boiling, nonferrous metallic impurities in the melt will inevitably lead to high concentrations of oxides of these metals in the fume. The cleanliness of the scrap is also an important factor.

The significance of these two factors was clearly shown by Coulter, who performed several tests under identical operating conditions but varied the cleanliness and quality of the scrap charged.[21] The quantity of emissions per ton of metal melted increased 100 percent when dirty, subquality scrap was used. This trend was substantiated by Kane and Sloan, whose tests, although marred by a malfunction, showed an increase of over 40 percent in the amount of emissions released per ton of metal processed when poorer quality scrap was charged to the furnace.[22]

The composition of particulate emissions from iron EAF's during melting and refining was determined for three iron foundries, as shown in Table 3-6. Iron oxide and silicon dioxide were the main components, with trace amounts of other metal oxides also present. Chemical analyses of dust collected from the bottom hopper of a fabric filter at a fourth iron foundry EAF are shown in Table 3-7. As indicated in Table 3-7, substantial quantities of oxides of manganese, aluminum, and magnesium were found in addition to iron and silicon oxides. Analysis of the same melting and refining samples for particle size indicated small median diameters.[23] Table 3-8 presents a summary of the particle size distribution obtained at each of the three iron foundries.

Particulate emission factors reported in the literature for uncontrolled emissions during the charging, melting, and tapping phases of electric arc furnace operation in iron foundries show large variations. Particulate levels ranging from 2 to 20 kg/Mg (4 to 40 lb/ton) of iron produced have been reported.[24,25] These variations are primarily attributable to the cleanliness of the scrap and foundry returns. Foundries that process relatively clean scrap and returns have lower emission factors.

A study was conducted for EPA covering all types of iron foundries.[3] It was concluded that, on the average, emissions from melting and refining at iron foundries are 7.0 kg/Mg (14 lb/ton) of iron produced.

Emissions from steel-producing furnaces are similar to those from iron melting. The dust generated in arc furnaces that melt steel for castings may have the composition shown in Table 3-9.

There are often traces of tin, zinc, chromium, and copper in the emissions. The use of larger amounts of galvanized scrap can result in higher levels of emissions of these metals.[27]

Oxygen lancing, when used in steel furnaces, temporarily increases gas volume as well as particulate and carbon monoxide emissions. Carbon

TABLE 3-6. CHEMICAL ANALYSIS OF PARTICULATE EMISSIONS FROM AN IRON ELECTRIC ARC FURNACE[23]

Constituent	Proportion of total particulate, weight percent		
	Foundry A	Foundry B	Foundry C
Iron oxide	75-85	74-85	75-85
Silicon dioxide	10	10	10
Magnesium oxide	2	0.8	1
Manganese oxide	2	2	2
Lead oxide	1	2	0.5
Alumina	0.5	1	0.5
Calcium oxide	0.3	0.2	0.8
Zinc oxide	0.2	2	0.3
Copper oxide	0.04	0.03	0.01
Lithium oxide	0.03	0.03	0.03
Tin oxide	0.03	0.3	0.02
Nickel oxide	0.02	0.03	0.01
Chromium oxide	0.02	0.07	0.01
Barium oxide	0.02	0.07	0.01

TABLE 3-7. COMPOSITION OF DUST COLLECTED BY FABRIC FILTERS AT AN IRON FOUNDRY[26]

Constituent		Weight percent
Ferrous oxide	(FeO)	8.75
Ferric oxide	(Fe_2O_3)	41.2
Silicon dioxide	(SiO_2)	34.9
Magnesium oxide	(MgO)	5.0
Aluminum oxide	(Al_2O_3)	4.7
Manganese dioxide	(MnO_2)	8.0
Calcium oxide	(CaO)	1.4

TABLE 3-8. PARTICLE SIZE DISTRIBUTIONS FOR PARTICULATE EMISSIONS FROM ELECTRIC ARC FURNACES AT THREE IRON FOUNDRIES[23]

	Cumulative percent by weight for indicated particle diameter		
Particle size (μm)	Foundry A	Foundry B	Foundry C
Smaller than 1	5	8	18
Smaller than 2	15	54	61
Smaller than 5	28	80	84
Smaller than 10	41	89	91
Smaller than 15	55	93	94
Smaller than 20	68	96	96
Smaller than 50	98	99	99

TABLE 3-9. STEEL ELECTRIC FURNACE DUST COMPOSITION[29-32]
(Weight Percent)

Components	Sample 1	Sample 2
Ferric oxide (Fe_2O_3)	35% to 42%	23.95%
Ferrous oxide (FeO)	4% to 8%	9.66%
Calcium oxide (CaO)	6% to 15%	15.41%
Aluminum oxide (Al_2O_3)	3% to 13%	--
Silicon oxide (SiO_2)	2% to 10%	3.76%
Manganese oxide (MnO)	2% to 8%	15.25%
Carbon (C)	2% to 8%	--

monoxide from lancing is typically combusted at the furnace by air drawn through furnace openings or by mixing furnace exhaust gases with outside air.[15] Unlike iron furnaces, steel furnaces may be backcharged which results in a violent eruption of iron oxide fume.

The average concentration of particulate at the inlet to control devices is in the range of 2.5 to 8.5 g/dscm (1.1 to 3.7 gr/dscf).* During oxygen lancing, peak values of 12 to 15 g/dscm (5.2 to 6.5 gr/dscf) are obtained. On the average, melting and refining emissions from steel furnaces are about 8.0 kg/Mg (16 lb/ton) of steel.[28] Peak emission rates which occur during oxygen lancing and backcharging are two or three times larger than the average.[15]

Table 3-10 presents a summary of emission factors for iron and steel producing electric arc furnaces.

3.3 BASELINE EMISSIONS

3.3.1 General

A summary of State air pollution regulations for those States having electric arc furnaces in foundries is presented in Table 3-11. Most of these States group foundries under the general heading of "Industrial" or "Manufacturing Processes" and regulate the class as a whole. Five States (Iowa, Michigan, New Hampshire, Virginia, and Wisconsin) have regulations specific to new and/or existing electric melting or foundry facilities (electric furnaces for metallurgical melting; secondary metal operations, including gray iron and steel foundries; electric arc or induction furnaces; or ferrous foundries with any melting procedure). Many other States have regulations that cover cupola furnaces in foundries but those regulations are not pertinent to this study.

The most common method of regulating particulate source emissions is through the use of one of two sets of process weight equations. They are:

1. $E = 3.59\,P^{0.62} \qquad P \leqq 30$

   $E = 17.31\,P^{0.16} \qquad P > 30$

---

*g/dcsm: grams per dry standard cubic meter.
gr/dscf: grains per dry standard cubic foot.

TABLE 3-10. SUMMARY OF EMISSION FACTORS FOR IRON- AND STEEL-PRODUCING ELECTRIC ARC FURNACES[7]

	Uncontrolled emissions			
	Iron furnaces		Steel furnaces	
	kg/Mg[a]	lb/ton[b]	kg/Mg	lb/ton
Melt and refine	7.0	14.0	8.0	16.0
Charge and tap	0.7[c]	1.4[c]	0.8	1.6

[a] kg/Mg = kilograms per megagram.
[b] lb/ton = pounds per ton.
[c] With alloys added to the ladle.

TABLE 3-11. SUMMARY OF STATE AIR POLLUTION REGULATIONS

EPA region	State	Particulate regulation	Appli-cation	Emission limit (lb/h) for indicated furnace size (tons/h)				Opacity regulation	Air pollution regulation reference
				4	10	25	50		
IV	Alabama	Equation set 1[a]	b	8.47	15.0	26.4	32.4	<20, exception	Chapter 4, 1976
		Equation set 2[c]	d	10.4	19.2	35.4	44.6	<20, exception	
		Controlled to extent reasonable	e					0 at lot line	
IX	Arizona	Equation set 2	f	10.4	19.2	35.4	44.6	<40	Chapter 3, 1978
		Equation set 1	g	8.47	15.0	26.4	32.4		
		Controlled to extent reasonable							
VI	Arkansas	Graph	h	80	130	190	260	<20	Section 5 and 8, 1975
		None	f					<40, exception	
IX	California								
	Bay Area	Equation set 3[i]	j	10.4	19.2	35.4	40	<20, exception	Regulation 2, 1970
	South Coast	Table	k	7.63	11.7	14.5	17.1	<20, exception	Regulation IV, 1976, 1977, 1978
VIII	Colorado	Equation set 1	f	8.47	15.0	26.4	32.4	≤20	Regulation 1, 1974
			e					0 at lot line	
			e					<20 at source, exception	
II	Connecticut	Equation set 1	f	8.47	15.0	26.4	32.4	<20, exception	Section 19-508-18, 1977
		Controlled to extent reasonable	e					0 at lot line	
III	Delaware	PM ≤0.20 gr/dscf[l]	f	m	m	m	m	<20, exception	Regulations V and XIV, 1977
		Table	n	6.0	15.0	37.5	--		
IV	Florida	Equation set 1	j	8.47	15.0	26.4	32.4	<20	Chapter 17-2, 1978
		Controlled to extent reasonable	e						
IV	Georgia		j					<40, exception	Chapter 391-3-1, 1975
		Equation set 2	h	10.4	19.2	35.4	44.6		
		$E = 4.1\ P^{0.67}$	f	10.4	19.2	35.4	56.4		
		Controlled to extent reasonable	e						
IX	Hawaii		f					<40, exception	Sections 8, 10, and 13, 1976
			h					<20, exception	
		Equation set 3	j	10.4	19.2	35.4	40.0		
		Controlled to extent reasonable	e						
X	Idaho		f					<40, exception	Chapters E, F, and H, 1976
			h					<20, exception	
		Equation set 2	j	10.4	19.2	35.4	44.6		
		Controlled to extent reasonable	e						

TABLE 3-11. SUMMARY OF STATE AIR POLLUTION REGULATIONS (continued)

EPA region	State	Particulate regulation	Application	Emission limit (lb/h) for indicated furnace size (tons/h)				Opacity regulation	Air pollution regulation reference
				4	10	25	50		
V	Illinois		j						
		Equation set 4[o]	h	5.33	8.69	14.2	20.5	≤30, exception	Rules 202 and 203, 1977
		Equation set 2	f	10.4	19.2	35.4	44.6		
		Particle size ≤40μ at lot line	e					0 at lot line	
V	Indiana	Equation set 2	j	10.4	19.2	35.4	44.6	≤40, exception	Regulations APC 3 and 5, 1978
VII	Iowa	Equation set 2	j	10.4	19.2	35.4	44.6	≤40	Chapter IV, 1978
		PM ≤0.1 gr/dscf	p	[m]	[m]	[m]	[m]		
VII	Kansas	Equation set 2	j	10.4	19.2	35.4	44.6	--	Section 28-19-20, 1974
IV	Kentucky	Equation set 1	h	8.47	15.0	26.4	32.4	<20	Sections 401 KAR 3:050 and 401 KAR 3:060, 1978
		Equation set 2	f	10.4	19.2	35.4	44.6	<40	
VI	Louisiana	Equation set 2	j	10.4	19.2	35.4	44.6	--	Section 19, 1978
		Controlled to extent reasonable	e						
III	Maryland	PM ≤0.03 gr/dscf	q	[m]	[m]	[m]	[m]	0	COMAR 10.18.02 through 10.18.07, 1975
		Equation set 5[r]	q	8.71	16.2	34.3	44.6		
		Equation set 5	s	8.71	16.2	34.3	44.6	≤20	
		PM ≤0.05 gr/dscf[t]	s	--	--	--	[m]		
		Controlled to extent feasible	e,q,s					0 at lot line	
		PM ≤0.03 gr/dscf	u	[m]	[m]	[m]	[m]		
		Controlled to extent feasible	e,u						
I	Massachusetts	Equation set 5[v]	f	8.71	16.2	34.3	44.6		Sections 7.01 and 7.06, 1978
		Equation set 6[v]	h	4.36	8.10	17.2	22.3		
			j					<20, exception	
		Not cause or create air pollution	e						
V	Michigan	Equation set 2	j	10.4	19.2	35.4	44.6	≤20, exception	Part 3, 1976
		PM ≤0.01 lb particulate per 1000 lb gas	p	[m]	[m]	[m]	[m]		
V	Minnesota		f					≤20, exception	Rule APC 5, 1976
		Equation set 1	j	8.47	15.0	26.4	32.4	≤20	
		Controlled to extent reasonable	e						
IV	Mississippi	Table	j	10.4	19.2	35.4	56.4	≤40	Regulation APC-S-1, 1975

TABLE 3-11. SUMMARY OF STATE AIR POLLUTION REGULATIONS (continued)

EPA region	State	Particulate regulation	Application	Emission limit (lb/h) for indicated furnace size (tons/h) 4	10	25	50	Opacity regulation	Air pollution regulation reference
VII	Missouri	Equation set 2	j	10.4	19.2	35.4	44.6		Regulation 10 CSR 10-3.050, 1975
		Ambient limits	e					0 at lot line	
IX	Nevada	Equation set 2	j	10.4	19.2	35.4	44.6	<20, exception	Articles 4 and 7, 1976
I	New Hampshire	Equation set 7[w]	x	12.8	23.6	43.6	53.5		Ferrous Foundries Regulation, 1974
		Equation set 2	y	10.4	19.2	35.4	44.6		
		PM ≤0.022 gr/dscf	y	m	m	m	m		
II	New Jersey	PM ≤0.02 gr/dscf or 99% reduction	j	m	m	m	m	≤20	Subchapter 6, 1977
II	New York	Equation set 8[z]	f	9.46	17.4	31.8	50.0	≤20	Sections 212.3, 212.4, and 212.7, 1973
		Equation set 9[aa]	h	9.56	17.4	31.8	m	≤20	
IV	North Carolina		f					≤40, exception	Sections 2 and 4, 1974
			h					≤20, exception	
		Equation set 2	j	10.4	19.2	35.4	44.6		
V	Ohio	Equation set 2	j	10.4	19.2	35.4	44.6	<20, exception	Regulations 3745-17-07 and 3745-17-11, 1977
		Controlled to extent reasonable	e					Same	
VI	Oklahoma	Equation set 2	j	10.4	19.2	35.4	44.6	≤20	Regulations 7 and 8, 1974
X	Oregon		f					<40, exception	Sections 21-014 and 21-035, 1976
			h					<20, exception	
		Equation set 5	j	8.71	16.2	34.3	44.6		
		Controlled to extent reasonable	e						
III	Pennsylvania	Equation 10[bb]	x	11.2	10.3	15.2	20.3	<20, exception	Sections 123.13 and 123.41, 1978
		PM ≤0.02 gr/dscf	j	m	m	m	m		
		No emissions	e						
IV	South Carolina	Equation set 2	j	10.4	19.2	35.4	44.6		Standard No. 4, 1978
IV	Tennessee		j					≤20, exception	Chapters 1200-3-5 and 1200-3-7, 1977
		Equation set 2	j	10.4	19.2	35.4	44.6		
		Equation set 1	h	8.47	15.0	26.4	32.4		
VI	Texas	Equation set 11[cc]	j	m	m	m	m		Regulation 1
								≤30	
			h					≤20	
		Ambient limits	e						

TABLE 3-11. SUMMARY OF STATE AIR POLLUTION REGULATIONS
(continued)

EPA region	State	Particulate regulation	Application	Emission limit (lb/h) for indicated furnace size (tons/h) 4	10	25	50	Opacity regulation	Air pollution regulation reference
VIII	Utah	85% particulate removal	f					≤40	Part II, 1977
			h					≤20	
I	Vermont		f					≤40, exception	Subchapter II, 1978
			h					≤20, exception	
		Table	j	8.71	16.2	34.3	40.0		
III	Virginia	Table	dd	10.4	19.2	35.4	44.6	≤20	Rules EX-2 and EX-4, 1977
		Controlled to extent reasonable	e						
X	Washington	PM ≤0.10 gr/dscf	j	m	m	m	m	≤20, exception	Regulations WAC 173-400-040 and WAC 173-400-060, 1976
V	Wisconsin	Equation Set 1	h	8.47	15.0	26.4	32.4	≤20	Rule NR 154.11, 1977
		PM ≤0.01 lb particulate per 1000 lb gas	ee	m	m	m	m		
		Controlled to extent reasonable							
VIII	Wyoming	Equation set 1	h	8.47	15.0	26.4	32.4	<20, exception	Chapter I, 1976
		Equation set 2	f	10.4	19.2	35.4	44.6	<40	
		Controlled to extent reasonable	e						

---

[a] 1. $E=3.59\ P^{0.62}$, $P \leq 30$

$E=17.31\ P^{0.16}$, $P \geq 30$

where E=particulate emissions rate in pounds per hour

P=process weight rate in tons per hour.

[b] Class 1 counties and new sources.

[c] 2. $E=4.10\ P^{0.67}$, $P \leq 30$

$E=55.0\ P^{0.11}-40$, $P > 30$

[d] Class 2 counties.

[e] Fugitive emssions.

[f] General existing source.

[g] Phoenix-Tuscon AQCR.

[h] New or modified equipment.

[i] 3. $E=4.10\ P^{0.67}$, $P \leq 30$; $E=40$, $P > 30$

[j] New and existing sources.

[k] All sources; summation of all process emissions; may be applied indoors.

[l] PM=particulate concentration in grains per dry standard cubic foot (gr/dscf).

[m] Depends on gas flow rate.

[n] Secondary metal operations.

[o] 4. $E=2.54\ P^{0.534}$, $P < 450$

$E=24.8\ P^{0.16}$, $P \geq 450$

[p] Electric furnaces for metallurgical melting.

[q] Areas I, II, V, and VI, new plants.

Reproduced from
best available copy.

TABLE 3-11. SUMMARY OF STATE AIR POLLUTION REGULATIONS
(concluded)

---

[r] 5. Table P ≤ 30

$E=55.0\ P^{0.11}-40$, $P>30$

[s] Areas I, II, V, and VI, existing and modified installations.

[t] $P>30$

[u] Areas III and IV, iron and steel production installations.

[v] 6. Table P ≤ 30

$E=1/2\ (55\ P^{0.11}-40)$ $P>30$.

[w] 7. $E=5.05\ P^{0.67}$ $P\leq 30$

$E=66.0\ P^{0.11}-48$ $P>30$.

[x] Existing ferrous foundry, any melting procedure.

[y] New or modified ferrous foundry, any melting procedure.

[z] 8. $E=0.024\ T^{0.665}$ $T\leq 100{,}000$

$E=39\ T^{0.082}-50$ $T>100{,}000$

where T=process weight rate per hour in pounds per hour.

[aa] 9. $E=0.024\ T^{0.665}$ $T\leq 100{,}000$

PM=0.03 gr/dscf $T>100{,}000$

[bb] 10. $E=0.76R^{0.42}$

where $R=F\times W$

F=process factor, pounds per unit

$P\leq 5$ tph=F=150 pounds per ton of iron

$P>5$ tph=F= 50 pounds per ton of iron

W=production or charging rate, units per hour.

[cc] 11. $E=0.048\ Q^{0.62}$

where Q=stack effluent rate in actual cubic feet per minute.

[dd] New and existing secondary metal operations (including steel and gray iron foundries).

[ee] Existing electric arc or induction furnace.

2. $E = 4.10\ P^{0.67}$ $\quad P \leqq 30$

$E = 55.0\ P^{0.11} - 40$ $\quad P > 30$

where E = allowable particulate emissions in lb/h

P = process weight rate in tons/h
(raw material input)

Equation set (2) is used by more States than equation set (1). Several of the States have calculated values for various process weight rates based on the equations and have generated tables or graphs for use in their regulation. These equations are used for existing and new and/or modified sources. Some States may use both equation sets depending on the source type. A few States have developed their own process weight equation.

Particulate emissions from both stack and fugitive sources may also be limited through the use of visible emission or opacity regulations. The maximum permissible opacities range generally from 20 to 40 percent; most States use 20 percent. Many of the States have specific time periods per hour or times per day exclusions during which the opacity may be greater, or even unlimited. In most States, the visible emissions are read at the emission point from the stack or building.

The State regulations pertaining to fugitive emissions are less specifically delineated. Of those States having fugitive emission regulations, most require the emissions to be controlled to the extent reasonable or feasible with no specific emission limit given. A few States specify an opacity either at the source or the plant boundary while others require only that the ambient particulate concentration limits not be exceeded. No specific control equipment is specified for process fugitive emissions although general requirements such as the hooding or ducting of emission sources may be recommended.

Facilities utilizing current best capture and control technology can meet the above process weight emission regulations (see Section 4.6 - Emission Source Test Data). The technology now commonly used for the capture of melting emissions is either a side draft hood (iron or steel foundry) or direct shell evacuation (steel foundry). Capture of fugitive emissions is less common, but where practiced, the canopy hood is the equipment usually used. In nearly all EAF foundries the control device used for particulate removal is the fabric filter. Depending on the extent of State Implementation Plan (SIP) revisions, the trend toward capture and control of fugitive emissions will probably continue in new foundries.

There are two regulatory approaches used by those States having the most strict regulations. Massachusetts and the California South Coast Air Quality Management District (SCAQMD) use process weight regulations with lower allowable pound per hour emission rates than the majority of the States. New Jersey and Pennsylvania specify an emission concentration limit of 45 mg/Nm^3 (0.02 gr/dscf), which is the lowest among States specifying concentration limits. Due to their dependence on air flow rates, concentration limits may provide stricter control than process weight limits for some capture devices but not for others.

The wording of the visible emission regulation of the California SCAQMD is stricter than that of any other State. Although the opacity limit is specified to be less than 20 percent, SCAQMD has defined "emissions to the atmosphere" to include emissions into the air in a building; therefore, the opacity measurements may be read in the building at the site of the process equipment, prior to diffusion into and/or out of the building.

3.3.2 Baseline Emission Level

The baseline emission level is taken to be that emission rate determined using the process weight equation:

$$E = 4.10\, P^{0.67} \qquad P \leq 30$$

$$E = 55.0\, P^{0.11} - 40 \qquad P > 30$$

where: E = allowable particulate emissions in lb/h
P = process weight rate in tons/h
(raw material input)

This emission rate would apply to melting emissions only. This equation is the most commonly used particulate source emission regulation that applies to iron and steel foundries. This equation is also used for all or part of regulations by 8 of the 13 States having 10 or more electric arc furnaces in steel foundries. These 8 States contain 17 of the top 36 foundry market areas, ranked by order of sales importance, including the top 6 areas.[2] The visible emission limit applicable to stack emissions is taken to be less than 20 percent.

Several States have fugitive emission regulations that could apply to electric arc furnace operations. However, compliance is difficult to determine because of the general wording of the regulations. No fugitive (charging, tapping) emissions would be controlled under the baseline emission level even though some fugitive control may now be practiced.

Table 3-12 presents representative emission rates for three furnace sizes for both iron and steel electric arc furnaces. The baseline emission level is given along with the uncontrolled emission level.

No regulations other than State and local air pollution regulations are believed to be a factor in the baseline emission level (e.g., Occupational Safety and Health Administration).

TABLE 3-12. MASS EMISSION RATES FOR IRON AND STEEL FOUNDRIES

			Iron			Steel		
A. Capacity	Mg/h (tons/h)		3.6 (4.0)	9.1 (10.0)	22.7 (25.0)	3.6 (4.0)	9.1 (10.0)	22.7 (25.0)
B. Uncontrolled emissions[a]								
Melting	kg/h (lb/h)	fugitive release	25.2 (55.6)	63.7 (140.4)	158.9 (350.3)	28.8 (63.5)	72.8 (160.5)	181.6 (400.4)
Charge/tap	kg/h (lb/h)	fugitive release	2.5 (5.5)	6.4 (14.0)	15.9 (35.0)	2.9 (6.4)	7.3 (16.0)	18.2 (40.0)
Total	kg/h (lb/h)		27.7 (61.1)	70.1 (154.4)	173.8 (385.3)	31.7 (69.9)	80.1 (176.6)	199.8 (440.4)
C. Baseline controlled emissions[b]								
Melting	kg/h (lb/h)	stack release	4.7 (10.4)	8.7 (19.2)	16.1 (35.4)	4.7 (10.4)	8.7 (19.2)	16.1 (35.4)
Charge/tap[c]	kg/h (lb/h)	fugitive release	2.5 (5.5)	6.4 (14.0)	15.9 (35.0)	2.9 (6.4)	7.3 (16.0)	18.2 (40.0)
Total[d]	kg/h (lb/h)		7.2 (15.9)	15.1 (33.2)	31.9 (70.4)	7.6 (16.8)	16.0 (35.2)	34.2 (75.4)

[a] From Table 3-10.

[b] $E = 4.0\ P^{0.67}$, $P \leq 30$.
$E = 55.0\ P^{0.11} - 40$, $P > 30$.
Where
E = particulate emissions, lb/h
P = process weight rate, tons/h

[c] No control required; therefore same as uncontrolled.

[d] Sum of controlled melting and uncontrolled charge/tap emissions.

3.4 REFERENCES FOR CHAPTER 3

1. Georgieff, N. T. and F. L. Bunyard. An Investigation of the Best Systems of Emission Reduction for Electric Arc Furnaces in the Gray Iron Foundry Industry. U.S. Environmental Protection Agency, Research Triangle Park, N.C. October 1976. Draft.

2. Foundry Management and Technology. Metal Casting Industry Census Guide, 1979 Edition. Cleveland. April 1979. 64 p.

3. Davis, J. A., E. E. Fletcher, R. L. Wenk, and A. R. Elsea. Screening Study on Cupolas and Electric Furnaces in Gray Iron Foundries. Final Report. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Contract No. 68-01-0611, Task No. 8. August 1975.

4. Steel Founder's Society of America. Directory of Steel Foundries in the United States, Canada, and Mexico, 1977-78. Rocky River, Ohio. 1977. 274 p.

5. 1979 U.S. Industrial Outlook. U.S. Department of Commerce, Industry and Trade Administration. Washington, D.C. January 1979. p. 178-179.

6. The Foundry Industry--A Look Ahead. Foundry Management and Technology. Miske, J. C. (ed.). Figure 3, p. 40. January 1978.

7. Fennelly, P. F. and P. D. Spawn. Air Pollutant Control Techniques for Electric Arc Furnaces in the Iron and Steel Foundry Industry. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. EPA-450/2-78-024. June 1978. 221 p.

8. Letter from Burgess, P., Hayes-Albion Corporation. Albion Malleable Division, to Georgieff, N. T., EPA. May 17, 1974. Information on malleable iron melting practice.

9. Letter from Ferguson, W. O., Gray and Ductile Iron Founders' Society, to Georgieff, N. T., EPA. May 29, 1974. Information on EAF iron melting emissions.

10. Letter from Ferguson, W. O., Gray and Ductile Iron Founders' Society, to Georgieff, N. T., EPA. October 14, 1975. Information on EAF melting emissions.

11. Bidulya, P. Steel Foundry Practice. Moscow, U.S.S.R., MIR Publishers, 1968. p. 295.

12. Letter and attachments from Welzel K., Landesanstalt fur Immissions und Bodennutzungsschutz des Landes Nordrhein-Westfalen, to Georgieff, N. T., EPA. June 16, 1976. Information on German EAF systems.

13. Rosenbach, V. K. and W. Bruchhauser. Erfahrungen mit der Rauchgasabsaugung und NaBreinigung durch Desintegrator an einem Lichtbogenofen. [Experiences with Waste Gas Removal and Wet Scrubbing Through a Disintegrator on an Electric Arc Furnace.] Stahl und Eisen (Dusseldorf). 86(1):16-21. January 13, 1966.

14. Background Information for Standards of Performance: Electric Arc Furnaces in the Steel Industry. Vol. 1. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EPA-450/2-74-017a. October 1974. p. 26.

15. Georgieff, N. T. Addendum to Standards Support and Environmental Impact for Electric Arc Furnaces in the Gray Iron Foundry Industry. U.S. Environmental Protection Agency. Research Triangle Park, N.C. December 1976. Unpublished.

16. Schwabe, W. E. New Developments in UHP: Theory and Practice. (Presented at International Conference on Electric Arc Furnaces in Steel Making. Cannes. June 7-9, 1971). 8 p.

17. James, A. I. Developments in Electric Furnace Plant and Operation. Crucible Induction Furnace Melting Plant at Sulzer Bros. GKN Birwelco (Uskside) Ltd. (Presented at 1972 British Cast Iron Association Meeting. University of Keele. October 3-5, 1972.)

18. Background Information for Standards of Performance: Electric Arc Furnaces in the Steel Industry. Vol. 2. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EPA-450/2-74-017b. October 1974. 41 p.

19. Memo from Goodwin, D. R., EPA, to Helms, G. T., EPA. November 25, 1974. Information on steel electric arc furnaces.

20. Lindstrom, R. N. and S. E. Sundberg. Fugitive Particulate Emission Rate and Characterization for Electric Arc Steelmaking Furnaces. Keystone Consolidated Industries, Inc., Peoria, Ill., and Particle Data Labs., Elmhurst, Ill. (Presented at Air Pollution Control Association Meeting. Cincinnati. June 24-29, 1979.) 15 p.

21. Coulter, R. S. Smoke, Dust, Fumes Closely Controlled in Electric Furnaces. The Iron Age. 173:107-110. January 14, 1954.

22. Kane, J. M. and R. V. Sloan. Fume Control -- Electric Melting Furnaces. American Foundryman. 18(5):33-35. November 1950.

23. Systems Analysis of Emissions and Emissions Control in the Iron Foundry Industry. Vol. 1. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EPA No. APTD-0644. February 1971.

24. Air Pollution Emissions and Control Technology-Iron and Steel Foundries Report. Prepared for Environment Canada, Air Pollution Control Directorate by Hatch Associates, Ltd., Toronto, Ontario. R-229. March 1975. 120 p. Draft report.

25. Systems Analysis of Emissions and Emissions Control in the Iron Foundry Industry. Vol. II. A. T. Kearney and Company, Inc. February 1971. Exhibit VI-16.

26. Memo and attachments from Jungers, R. H., EPA, to Bibb, T., EPA. September 26, 1975. Gray iron foundry sample analysis.

27. Schmidt, K. G. Staubbekampfung in der GieBerei-Industrie. [Dust Abatement in the Foundry Industry.] Dusseldorf, VDI-Verlag, 1967. p. 358.

28. Baum, K. Removal of Dust from Electric Furnace Waste Gases. Stahl und Eisen (Dusseldorf). 84(11):1497-1500. November 1964.

29. Doerschuk, V. C. How to Control Emissions from Electric Steel Melting Furnaces: Part I. Air Engineering. 9:53-57. September 1960.

30. Doerschuk, V. C. How to Control Emissions from Electric Steel Melting Furnaces: Part II. Air Engineering. 10:42-46. October 1960.

31. Pring, R. T. Control of Fume from Electric Steel Melting Furnaces: Part I. Air Conditioning, Heating and Ventilating. 58:45-50. January 1961.

32. Pring, R.T. Control of Fume from Electric Steel Melting Furnaces: Part II. Air Conditioning, Heating, and Ventilating. 58:121-125. February 1961.

4. EMISSION CONTROL TECHNIQUES

4.1 INTRODUCTION

Control of emissions from electric arc furnaces in foundries results from the efficiency of two completely separate operations. The first operation is the capture or containment of the exhaust gas stream from the furnace. The second operation is the removal of contaminants from the exhaust gas stream. Capture poses two separate problems in the process operation itself: capture of emissions during charging and tapping (fugitive emissions), and capture of emissions during melting and refining (process emissions).

Historically, the control of emissions from electric arc furnaces has progressed through several stages. Prior to the development of more sophisticated control techniques, hot air and emissions were allowed to rise to the roof of the shop where they were vented through louvres or fans into the atmosphere. Although this procedure cleared the melting shop of emissions and heat, it merely transferred the emissions outside and resulted in complaints from residents of the surrounding area. Large, expensive fans were required for effective venting of the hot air and emissions.

In order to reduce the exhaust volume and permit the use of less expensive fans, roof trusses were enclosed and equipped with baffles directly above the furnace. This modification reduced the required exhaust volume, but the amount of dust discharged remained unchanged.

The next stage in the development of emission control techniques was the installation of small canopy hoods above the furnaces in conjunction with a relatively inefficient control device to remove pollutants from the hot gases. The gas volume was still large and required expensive, high volume collection systems and control devices. Use of small canopy hoods also did not entirely solve the problem of in-plant air pollution. Strong cross-drafts (caused by open doors) within the building disturbed the flow pattern of the gases from the furnace causing some emissions to bypass the hood and drift to the roof area. These emissions would occasionally flow downward toward the floor too rapidly to be removed by exhaust fans. Under such conditions, the overhead crane operator's vision was sometimes impaired, and dangerous operating conditions existed in all parts of the electric furnace bay area.

Subsequently, attempts have been made to reduce exhaust volumes as much as possible by mounting hoods closer to the furnace or by directly evacuating the furnace itself (direct furnace evacuation system). Although moving the hoods closer to the furnace roof reduces the volume of air to be captured and cleaned, this control technique is not totally effective during charging or tapping.

This chapter presents emission capture techniques in common use for charging, melting and refining, and tapping, respectively. Control of emissions from the melting phase of furnace operation is currently practiced at most foundries. Control of emissions from charging and tapping is not widely practiced at existing foundries. New designs, which may be feasible for capture of emissions during charging and tapping, have been installed on several EAF's. In addition, several designs for control of emissions during charging and tapping have been developed and are also addressed in this chapter. Finally, this chapter details exhaust gas cleaning devices and summarizes test data for currently used emission control techniques.

4.2 CONTROL OF CHARGING EMISSIONS

Electric arc furnaces are typically charged by removing the entire roof-electrode-fume hood assembly and dropping scrap into the furnace with drop-bottom charging buckets.[1] As scrap contacts the hot furnace, fumes consisting of hydrocarbon vapors and soot (from entrained oil), iron oxides (from splashing and oxidation of iron), and smoke (from dirt on the scrap) are generated. Charging emissions have traditionally been vented to the atmosphere through roof monitors, since conventional emission collection devices only collect melting emissions. However, charging often results in substantial visible emissions, and it is becoming more common for regulatory agencies to require control of charging operations by visible or fugitive emission regulations.

There are five basic techniques applicable for capturing charging emissions:

1. canopy hoods;
2. building evacuation;
3. bay evacuation;
4. furnace enclosures; and
5. specially designed, "close capture" hoods.

Each technique may also apply to the control of tapping emissions, which is discussed in Section 4.4. Additional techniques are available for control of charging emissions. For example, charging emissions can be reduced by the use of clean scrap. Although most foundries seek high quality scrap, dirty scrap can be cleaned prior to charging by preheaters or a degreasing process. Degreasing is an expensive process that is seldom used. Conceptual designs (not yet in use at foundries) for collecting charging emissions include the hooded charge bucket and closed charging systems. The following subsections describe each control technique.

4.2.1 Canopy Hood

The canopy hood is the most common device currently in use for the collection of charging emissions at foundries. Located above the overhead crane, canopies are normally operated only during charging and tapping, when the melting collection system is inoperative. However, some air may be drawn through the canopy hood even during melting. A typical canopy hood collector is illustrated in Figure 4-1.

The configuration and proper location of a canopy hood is dependent mainly on structural and geometrical considerations within the shop. The most effective position to place a canopy hood is as close to the furnace as possible, although clearance for overhead cranes and furnace electrodes must also be available. Canopies are usually suspended 7 to 14 meters (m) [23 to 46 feet (ft)] above the furnace or attached directly to the shop roof. Umbrella-shaped hoods of a diameter larger than the furnace are one design option, while other designs incorporate the foundry roof

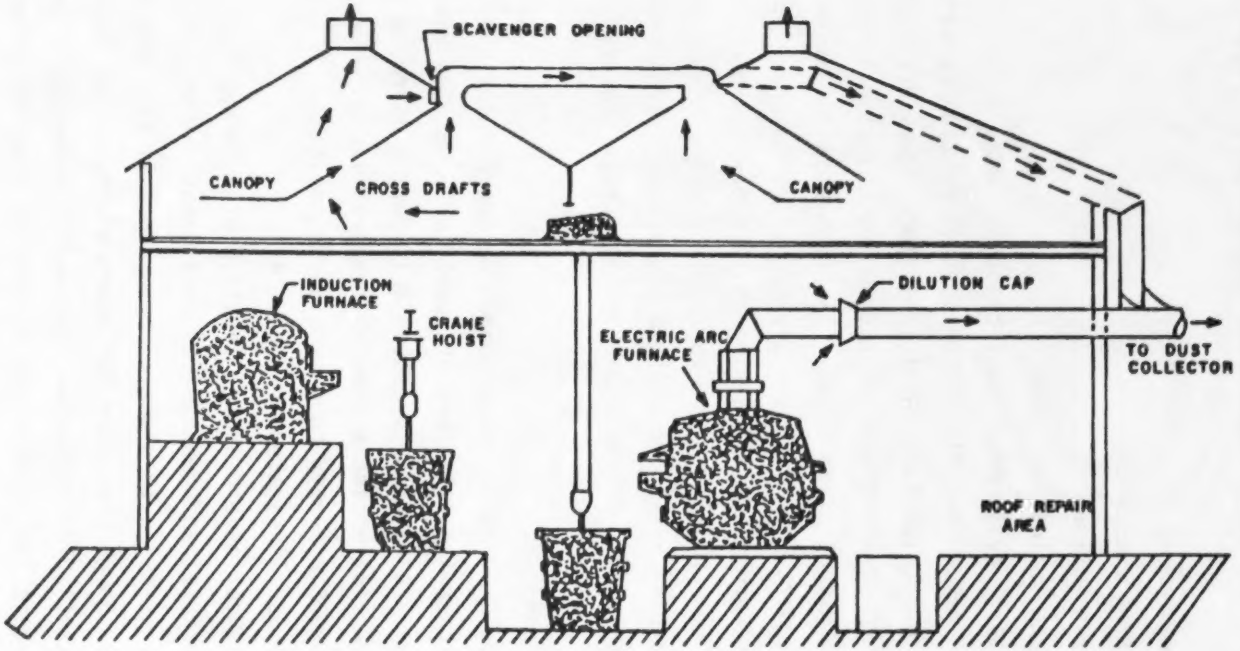

SCAVENGER OPENING
CANOPY
CROSS DRAFTS
CANOPY
INDUCTION FURNACE
CRANE HOIST
ELECTRIC ARC FURNACE
DILUTION CAP
TO DUST COLLECTOR
ROOF REPAIR AREA

Figure 4-1. Canopy hood using building roof as part of the canopy, combined with direct furnace evacuation.[1]

and side walls. The canopy can be constructed in sections with separate dampers to control the air suction exerted by each section. The dampers can then be preset or controlled by an operator to provide a greater suction to areas where the largest quantity of emissions is generated.

Due to the positioning of the hood, the volume of air drawn through it must be large to ensure effective capture of emissions. Although thermal currents from the hot furnace help direct emissions upwards to the canopy, the flow rate necessary for adequate capture is several times greater than that required for control of melting emissions. Consequently, the size and costs of a final gas cleaning device are substantially increased over costs for melting control alone.

Effective capture of emissions is not always attained by the use of a canopy hood. As the furnace is charged, emissions are sometimes diverted away from the canopy because of impingement on overhead cranes and the charge bucket. Another problem is caused by cross-drafts in the shop, which lower canopy hood collection efficiency. Upward flow of the emission plume from the furnace is easily disrupted by drafts from openings along foundry walls and doors, passage of shop vehicles, temperature gradients within the shop, and even suction hoods which may ventilate other nearby foundry processes. A canopy hood is not generally as effective for small furnaces because there is less thermal uplift generated. Meteorological conditions may also influence the plume conditions. High pressure systems and low humidity tend to allow efficient upward flow of the plume to the canopy. However, during periods of low pressure, high humidity, and/or strong winds, thermal columns above the furnace may not be sufficient to carry fumes directly into the canopy.

Several techniques have been used to reduce the effects of cross-drafts and improve the upward flow of emissions to the canopy. At foundries, scavenger openings (see Figure 4-1) may be provided immediately above the canopy in the exhaust ductwork to collect emissions which have escaped hood capture and have accumulated under the shop roof. Curtain walls constructed of sheet metal have been used to screen sensitive portions of a steelmaking furnace area from drafts and improve upward flow of charging emissions.[2] This may be termed a modified canopy hood or a partial enclosure at some facilities. Another technique recently applied to both foundry and steelmaking EAF's is the use of an air curtain.[3,4] An upward flow (or curtain) of air is directed around the furnace to contain and help direct fumes to the canopy. Mobile air curtains have provided an effective method for counteracting daily variations in cross-draft flow patterns at a steelmaking shop.[5] Unfortunately, the air curtain often cannot completely overcome the force of cross-drafts.

Control of cross-drafts often involves modifying shop ventilation systems. For example, the exhaust hood on a pouring line adjacent to a furnace may create a negative pressure which impedes upward air flow from the furnace. At many foundries, the scrap handling area is adjacent to the furnace and has large doors which open to the atmosphere. Influence of outside winds on canopy efficiency can be reduced by closing these and other openings in the foundry walls.

The particulate collection and removal efficiency attainable with canopy hoods were evaluated during a research and development program conducted by a large British steel company.[6] It was determined that 90 to 100 percent of charging (and tapping) emissions were collected under optimum conditions (no serious crosswinds in the shop). During periods of strong prevailing winds outside the shop, up to 30 percent of charging (and tapping) emissions drifted away from the canopy. To control the influence of cross-drafts deflecting the rising plume, vertical sheeting was installed over the entire length of a four-furnace melt shop, roof vents were blocked off, and doors fitted on large openings in the shop wall.

Exhaust flow rates and emission capture efficiencies for canopy hoods and other capture techniques for charging (and tapping) emissions are summarized in Table 4-1. Exhaust requirements for canopies are high, ranging from about 65 m^3/s (138,000 ft^3/min) for a 3.6-Mg/h furnace to 81 m^3/s (171,600 ft^3/min) for the 22.7-Mg/h furnace. Larger furnaces require proportionally less flow than the smaller furnaces because of the benefits of thermal uplift provided by the larger heat source. The flow rates shown are averages of typical values since the physical layout of a particular foundry dictates its canopy location, size, and design flow rate. Capture efficiency of the canopy hood is specified as 80 to

TABLE 4-1. TYPICAL EXHAUST FLOW RATES AND EMISSION CAPTURE EFFICIENCY OF CHARGING AND TAPPING CONTROL DEVICES AT MODEL FOUNDRIES

	Typical exhaust flow rate for model furnaces in m^3/s (ft^3/min)			Emission capture efficiency (percent)	
	Model furnace size				
	3.6 Mg/h (4 ton/h)	9.1 Mg/h (10 ton/h)	22.7 Mg/h (25 ton/h)	Range	Typical maximum
Canopy hoods, charge and tap[6,7]	65.1 (138,000)	73.2 (155,100)	81.0 (171,600)	15-90[a]	80
Building evacuation, charge and tap[7,8]	81.0 (171,600)	91.5 (193,900)	101 (214,000)	95-100	99
Furnace enclosure charge[b] Furnace enclosure tap[b]	8.0 (17,000)	11.8 (25,000)	28.3 (60,000)	50-80[10] 80-95[10]	80[10] 90[7]
Close capture hoods, charge and tap[7]	13.0 (27,500)	19.8 (42,000)	50.0 (106,000)	60-90	80[c]
Ladle pit enclosure, tap only[7]	13.0 (27,500)	19.8 (42,000)	50.0 (106,000)	80-100[11]	99[7]

[a] Collection efficiency substantially reduced if cross-drafts are present in shop.

[b] Reference 9 for 3.6 and 9.1 Mg/h flow rates; Reference 7 for 22.7 Mg/h flow rate.

[c] Tapping efficiency considerably reduced with increasing alloy additions to ladle; i.e., at steel furnaces.

90 percent, with 80 percent considered a more typical value because of the potential for deflection by crosswinds. Efficiency can be much lower for improperly designed canopies, especially in shops which do not control cross-drafts. Using the typical flow rates in Table 4-1, it can be calculated that a net increase in emissions to the atmosphere can occur if the power plant emissions generated as a result of the electrical requirements of the canopy hood are considered for the 3.6-Mg/h (4-ton/h) furnace.[12]

Retrofitting an existing furnace with canopy hoods sometimes requires extensive structural modifications. Trusswork and roof beams must often be relocated, reconstructed, and/or strengthened to accommodate the canopy and exhaust ductwork. In some shops, there may not be enough clearance between the crane and the roof, or the roof configuration itself may not be adaptable to a canopy installation. Also, space must be provided for the large baghouse required to handle the high exhaust volume.

4.2.2 Building Evacuation

Several large iron foundries operate ventilation systems which completely evacuate the shop--exhausting emissions from charging, tapping, and other foundry operations to a gas cleaning device.[3,13] Building evacuation systems are similar to canopy hoods but operate at greater flow rates. Building evacuation systems exhaust emissions which accumulate under the shop roof (see Figure 4-2). Factors which influence the installation of a building evacuation system over other systems for control of charging emissions are:

1. structural limitations or insufficient space to use a canopy hood;
2. need to collect fugitive or miscellaneous emissions;
3. a roof configuration well-suited to complete evacuation (often, the roof can be modified to serve as a collection hood, as shown previously in Figure 4-1); and
4. desire to exhaust the entire foundry internal atmosphere to reduce pollutant concentration for reasons of industrial hygiene, to reduce heat stress, or for metallurgical reasons.

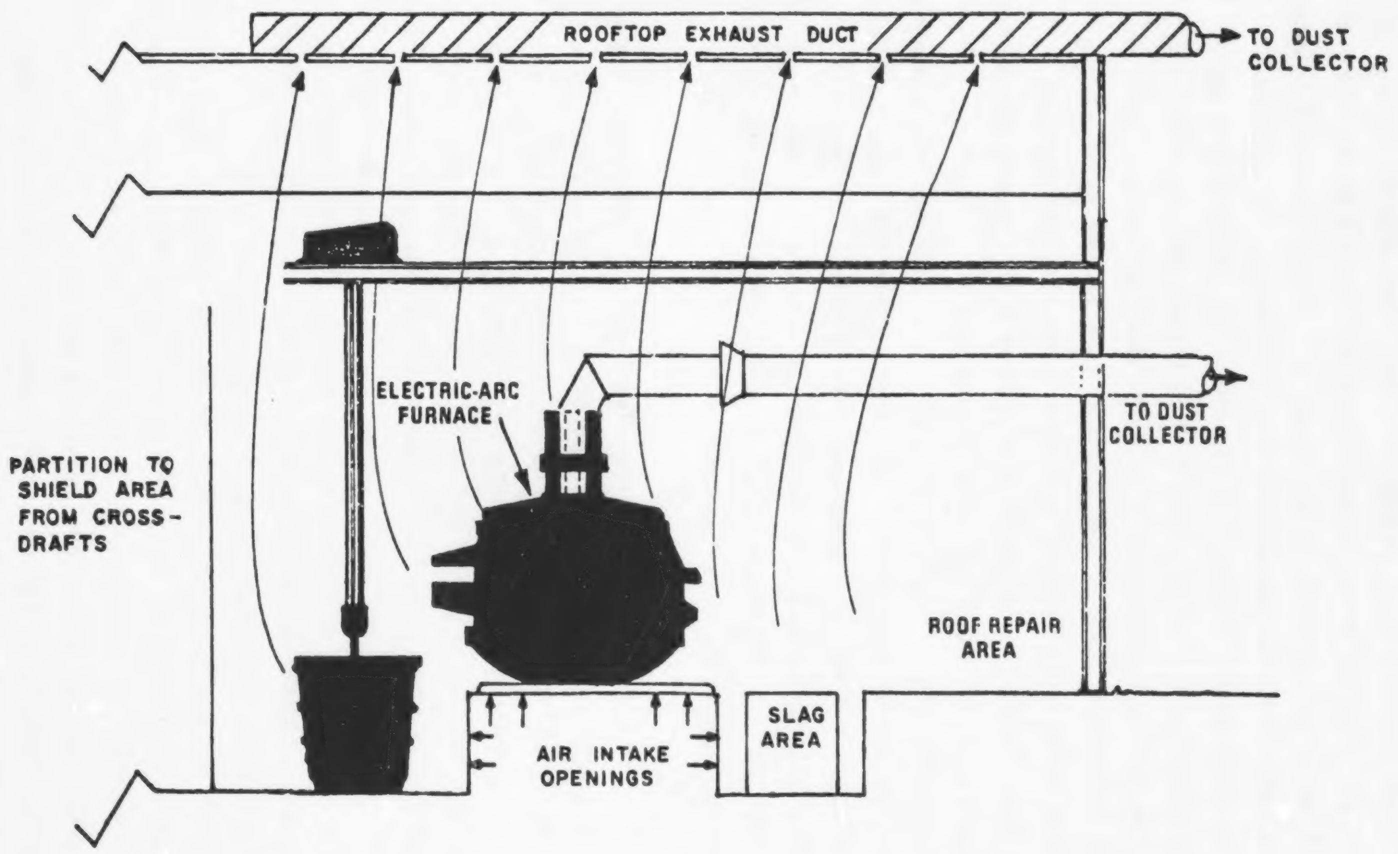

ROOFTOP EXHAUST DUCT
TO DUST COLLECTOR
ELECTRIC-ARC FURNACE
TO DUST COLLECTOR
PARTITION TO SHIELD AREA FROM CROSS-DRAFTS
ROOF REPAIR AREA
SLAG AREA
AIR INTAKE OPENINGS

Figure 4-2. Design aspects of building evacuation system.[1]

Major considerations in the design of a building evacuation system are control of air flow patterns through the building and maintenance of an effective flow rate. Ideally, floor level air inlets surround sources of heat and the emissions are exhausted to a central outlet located overhead in the shop roof. However, differences in air duct placement are usually necessary because of structural and shop operational constraints. Excessive turbulence and dead zones must be avoided to ensure proper removal of contaminants. Flow control is enhanced by isolating emission sources with partitions constructed to provide the maximum feasible emission containment without interfering with foundry operations. These concepts are illustrated in Figure 4-2.

Air velocity through inlet openings of the building must be adequate to induce air flow through the proper locations within the shop. Louvers or vertical adjustable doors are sometimes used as air inlet openings through building external walls. Air outlets in the roof can be designed to avoid the necessity for large evacuation hoods, relying on the building roof truss area or plenum as a contaminant reservoir and collection chamber

The volume of air typically withdrawn for building evacuation systems is difficult to generalize because each foundry is of a different size and building configuration. Five air changes per hour have been used at some steel mills to maintain a clean internal atmosphere.[14] The number of air changes per hour at a given shop may be considerably more than this, depending on the shop conditions. Data developed for steelmaking EAF shops show that typical building evacuation systems evacuate about 25 percent more air than an efficient canopy hood.[1] This criterion was used for flow rates summarized in Table 4-1: 81 m^3/s (171,600 ft^3/min) for the small 3.6-Mg/h (4-ton/h) furnace, ranging to 101 m^3/s (214,000 ft^3/min) for the large 22.7-Mg/h (25-ton/h) furnace. Emission capture efficiency is listed in Table 4-1 as typically 99 percent, ranging from 95 to 100 percent, in recognition of the fact that a few small openings may exist through which some emissions escape.

Since the air flow rates for building evacuation are greater than those for canopy hoods, the control device would also be larger than that for the canopy hood. In addition, a net increase in emissions to the atmosphere would be possible when building evacuation systems are used on a 3.6-Mg/h (4-ton/h) furnace.[15]

There is a trend towards enclosing roof monitor vents to contain charging, tapping, and other fugitive emissions and to avoid violation of visible emission codes. A multiple, manifold-type exhaust system ducts emissions to the gas cleaning device. This system is not designed as a complete building evacuation system but is designed merely to remove contaminants which accumulate under the shop roof. Fugitive furnace emissions are eliminated at an exhaust flow rate somewhat less than that of complete building evacuation systems since the exhaust flow rate is adequate to remove only accumulated emissions, not to evacuate the entire building. Although most emissions are collected and removed, a small amount could escape the foundry through open windows and doors. The Michigan casting facility of Ford Motor Company is an example of this type of control.[16]

4.2.3 Bay Evacuation

A recent variation of the building evacuation capture system is the bay evacuation system where each shop bay (e.g., furnace, ladle, casting, stripping) is evacuated separately.[17,18] The furnace is located in a windowless room (bay) isolated from other bays by air locks and/or soundproof doors. The furnace bay roof is shaped to accommodate a canopy hood for fugitive emission control (see Figure 4-3). The canopy hood may be zoned so that proper airflow may be maintained during charging and tapping. If more than one furnace is contained in the bay, each may have its own canopy hood. A bay evacuation system would greatly reduce the problems involved with cross-drafts that are encountered with canopy hood and building evacuation systems.

This system is in use in at least three European steel mills but is not known to be used in foundry operations either in the United States or abroad. Thus, little extrapolation can be done with regard to the volume of air required to remove the emissions since this air volume would depend on the size and configuration of the individual shop. Some comparison can be made, however, for the 22.7-Mg (25-ton) furnace size. One of the European facilities evacuates 64 m^3/s (135,000 ft^3/min) for a 22.7-Mg (25-ton) furnace.[18] This figure falls within the range of those shown in

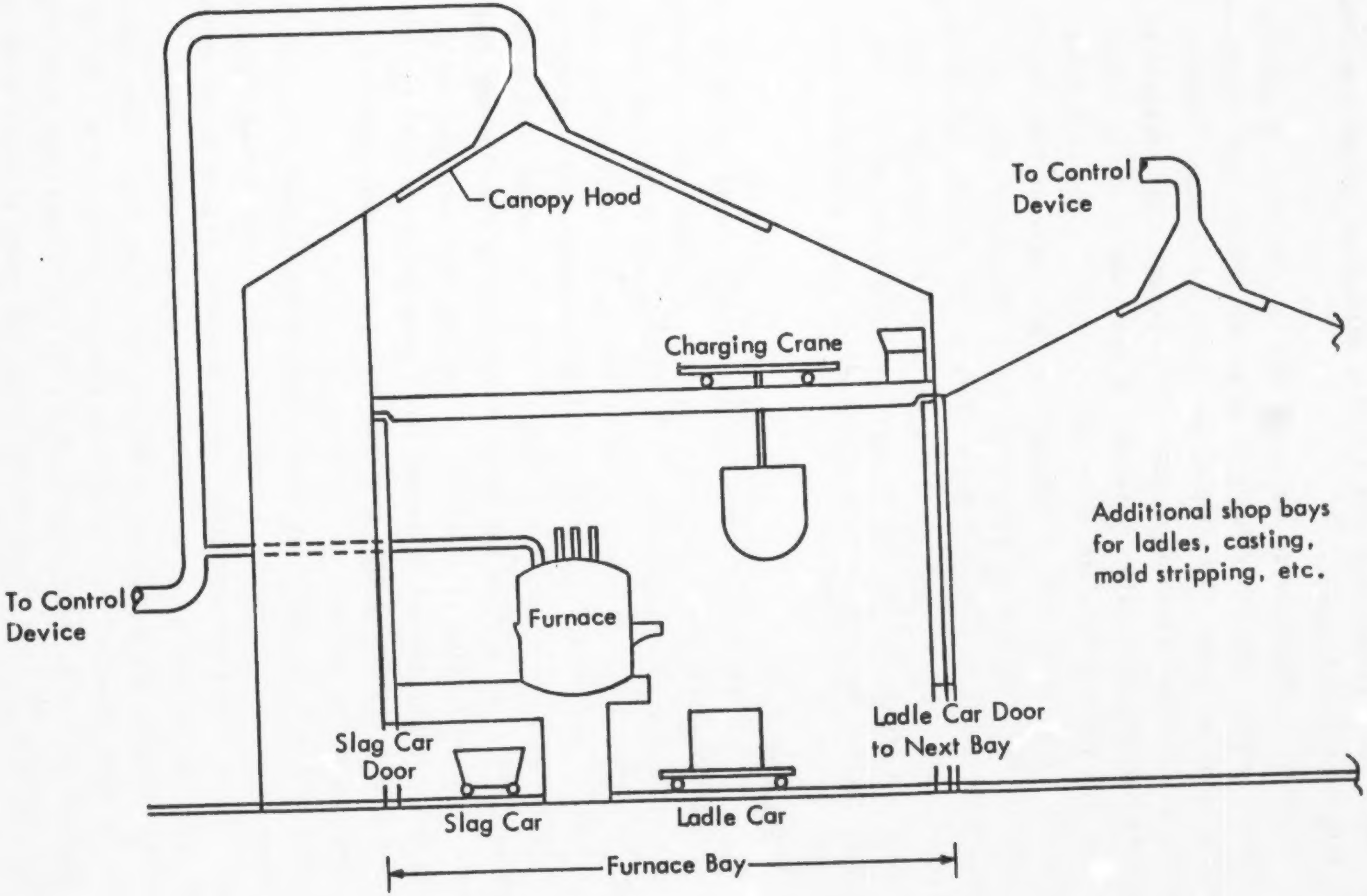

Canopy Hood
To Control Device
Charging Crane
Additional shop bays for ladles, casting, mold stripping, etc.
To Control Device
Furnace
Slag Car Door
Ladle Car Door to Next Bay
Slag Car
Ladle Car
Furnace Bay

Figure 4-3. Schematic diagram of bay evacuation system.[18]

Table 4-1 for 22.7-Mg (25-ton) model furnaces. The emission capture efficiency of the bay evacuation system is not known but it should be in the same range as that for building evacuation systems.

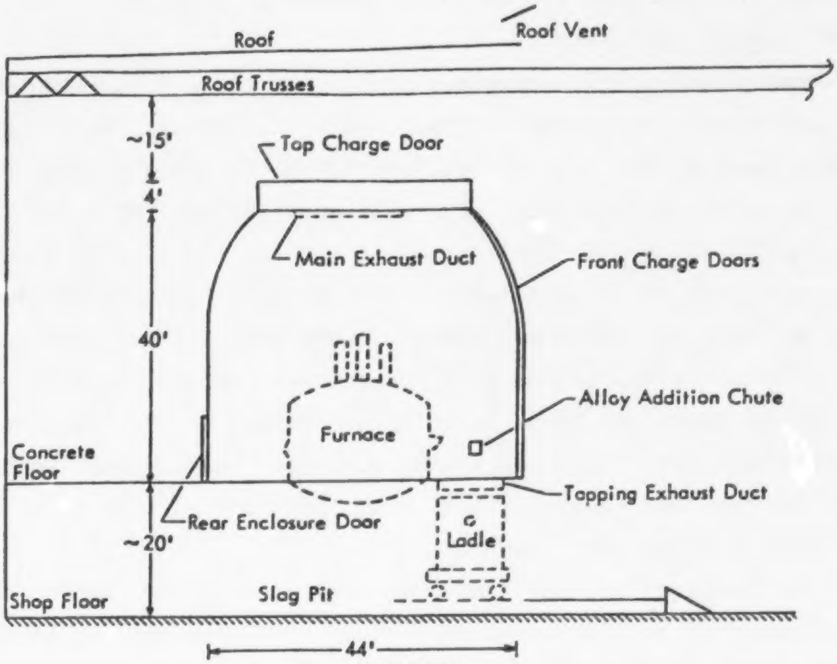
4.2.4 Furnace Enclosure

A metal shell which completely encloses the furnace and tapping area can capture emissions from charging, melting, and tapping (Figure 4-4). A large takeoff duct near the enclosure top removes charging and melting emissions while a separate, local duct contains tapping fumes.

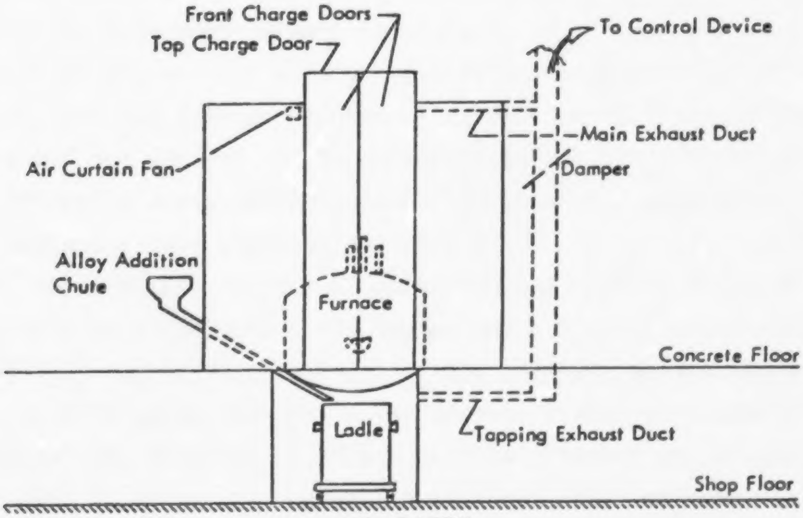
The first domestic application of the furnace enclosure concept began operation in 1976 on two 54.4-Mg (60-ton) capacity steelmaking EAF's at the Lone Star Steel Company, Lone Star, Texas. The furnaces are part of a new melt shop and each furnace was enclosed as an economical alternative to canopy hoods or building evacuation for the control of fugitive emissions. A furnace enclosure has recently been installed in a steel foundry, and several others are under construction or on order for use on EAF's in foundry shops.

The volume of air which must be removed from the furnace enclosure is estimated at only 30 to 40 percent of that required for an efficient canopy hood, considerably reducing both capital and operating costs for exhaust ductwork, fans, and gas cleaning equipment. Major factors which reduce effectiveness of a canopy hood, namely, cross-drafts and diversion of fumes by the crane, are eliminated with a furnace enclosure. As a secondary benefit, furnace noise is reduced outside the enclosure.

Figure 4-4 shows the basic design of the furnace enclosure at Lone Star Steel Company, and pertinent design parameters are summarized in Table 4-2. Constructed of riveted steel plates, each enclosure is a cube with a domed or rounded top measuring 13.4 m (44 ft) on edge. The enclosures contain the minimum volume which provides clearance for furnace roof removal during charging and for furnace electrodes when tilted for a tap. Pneumatic cylinders operate large vertical doors on the front of the enclosure; an electric motor operates a segmented, horizontal, cable-guided top door to allow conventional furnace charging by crane. Smaller vertical doors at the rear of the enclosure allow access for oxygen lancing, slagging, and chemical additions.


Roof
Roof Vent
Roof Trusses
~15'
Top Charge Door
4'
Main Exhaust Duct
Front Charge Doors
40'
Furnace
Alloy Addition Chute
Concrete Floor
Tapping Exhaust Duct
Rear Enclosure Door
Ladle
~20'
Shop Floor
Slag Pit
44'

SIDE VIEW


Front Charge Doors
Top Charge Door
To Control Device
Main Exhaust Duct
Air Curtain Fan
Damper
Alloy Addition Chute
Furnace
Concrete Floor
Ladle
Tapping Exhaust Duct
Shop Floor

FRONT VIEW

Figure 4-4. Sketch of furnace enclosure design at Lone Star Steel Co.[19]

TABLE 4-2. DESIGN DATA FOR LONE STAR STEEL COMPANY FURNACE ENCLOSURE[19]

I. Steelmaking facilities

Two 54.5 Mg (60 ton) Whiting EAF's, each enclosed in 3230 m^3 (114,000 ft^3) enclosure. Enclosures measure 13.4 m (44 ft) on edge; furnaces are 6.1 m (20 ft) above ground level. Average 2-1/2 hours per heat.

II. Gas flow rate, per enclosure

Charge, melt, refine, and tap: 35 to 42 m^3/s (75,000 to 90,000 ft^3/min)

III. Exhaust gas temperatures

A. Charge, melt, and refine: 80°C (175°F)

B. Tap: 120°C (250°F)

IV. Dust concentration measured by Lone Star Steel Company (EPA Method 5)

A. Inlet to scrubber: 2.29 g/m^3 (1.0 gr/ft^3)

B. Outlet from scrubber: 0.024 g/m^3 (0.0045 gr/ft^3)

V. Suction required

Inlet to scrubber units: 1.4 cm Hg (7.5 in. H_2O)

VI. Capital cost[a]

A. Enclosures, ducting, and auxiliary equipment, including gas cleaning device: $900,000 per enclosure

B. Scrubber gas cleaning units only: $200,000 per enclosure[b]

---

[a] 1976 dollars.
[b] Utilized existing waste heat boiler and slurry treatment facilities.

During positioning of the charge bucket, the crane operator has a line of sight to the furnace through the top enclosure doors. When a charge is dropped into the furnace, the front doors are closed but the top door remains open. A fan-type air curtain directs the emission plume past the open top doors to the exhaust duct. During melting, the top and front charge doors are closed and the emissions are exhausted from the enclosure by a large rectangular exhaust duct located above the furnace 1.2 m (4 ft) below the enclosure top. Between 35 and 42 m^3/s (75,000 and 90,000 ft^3/min) of air is withdrawn from each enclosure by suction developed by Lone Star's proprietary scrubber which cleans the furnace exhaust gases. Slagging, chemical additions, and oxygen lancing are conducted through a third door at the furnace rear. This door is currently left open during the entire process.[10] The furnace is tapped into a ladle which is placed on a railcar by the overhead crane, then rolled into position under the enclosure. Tapping emissions are collected by diverting flow from the main exhaust duct to a duct which is adjacent to the ladle. Both furnaces and enclosures rest on a platform about 6.3 m (20 ft) above the melt shop floor. This provides room for the tapping ladle car and also provides air flow from underneath the furnaces to effectively carry contaminated gases to the main exhaust duct. The elevated furnace and ladle car were provided for the Lone Star installation but are not necessary to, nor integral parts of, the total enclosure concept.

Lone Star Steel operators have encountered no major problems in using the enclosures. Lone Star has run trial heats charging No. 2 bundles (automobile bodies processed through a compactor). Because of combustion of contaminating oil and organic matter, flames from the hot furnace reached to the top of the enclosure. Lone Star personnel indicated that the trial runs showed that additional enclosure height would be necessary if dirty scrap is used routinely. Other methods of protecting the structure from the heat (e.g., the use of alternate materials or shielding) could also be used. When clean scrap is charged, about 95 to 99 percent of the charging emissions appear to be collected. This estimate is based on observations by engineers who visited Lone Star Steel on behalf of EPA in 1977 and on statements by plant engineers and the local air pollution control agency.[19] When ordinary purchased scrap (other than clean) is charged, the capture efficiency drops to 50 to 80 percent. This estimate is based on observations by engineers who visited the facility in 1979.[10] The charging process at this facility lasted approximately two minutes. Visible emission observations were made of the total enclosure emissions, but, as information to reconcile the above conflicting observations is not available, these visible emission data are not presented in this document.[20] This enclosure installation was the only one operational at the time of the study; thus, no further information could be obtained regarding the capture efficiencies.

An enclosure system of a different design was installed in a steel foundry during the summer of 1979 but was not operational at the time of this study.[21-23] This system is on a 5.4-Mg (6-ton) capacity basic EAF at Certified Alloy Products, Inc., Long Beach, California. Pertinent design parameters are summarized in Table 4-3. Constructed of steel plate and sheeting, the enclosure dimensions are 5.8 by 8.8 m (19 by 29 ft). The inside of the enclosure is covered with insulation for sound proofing. Air-operated doors are used to allow access of the charge bucket while manually operated doors allow personnel entrance (e.g., for slagging and bath sampling). No air curtain is used during charging, and the end and roof doors are open during both charging and tapping. Air is evacuated at a rate of 18.9 m^3/s (40,000 ft^3/min) from the enclosure for emission control purposes. The gas stream is cleaned in a fabric filter.

Another steelmaking EAF enclosure is in use in Europe.[24] This system, shown in Figure 4-5, is offered by the Krupp Company. It relies on an enclosure somewhat larger than the one at Lone Star Steel. A direct roof evacuation tap supplements emission control during melting. Instead of sliding doors, a section of the enclosure side wall moves horizontally to allow passage of a specially designed charging crane. The crane is designed with a section which seals the enclosure during charging (see Figure 4-5). Procedures for tapping and alloy additions are similar to methods used at Lone Star. Available data indicate that the enclosure volume for a 128-Mg (140-ton) steel EAF is 11,000 m^3 (388,000 ft^3), and the enclosure exhaust rate is 135 m^3/s (290,000 ft^3/min) during charging and tapping and 105 m^3/s (226,000 ft^3/min) during melting.

TABLE 4-3. DESIGN DATA FOR CERTIFIED ALLOY PRODUCTS FURNACE ENCLOSURE[23]

I. Furnace facilities

One 5.4-Mg (6-ton) Lectromelt EAF located in an enclosure having dimensions of 5.8 by 8.8 m (19 by 29 ft). Average 3 hours per heat.

II. Gas flow rate

18.9 m^3/s (40,000 ft^3/min)

III. Exhaust gas temperature

54°C (130°F) maximum

IV. Capital cost[a]

A. Enclosure, ductwork, fans, auxiliary equipment:	$159,000
B. Fabric filter:	$ 95,000

---

[a] 1979 dollars.

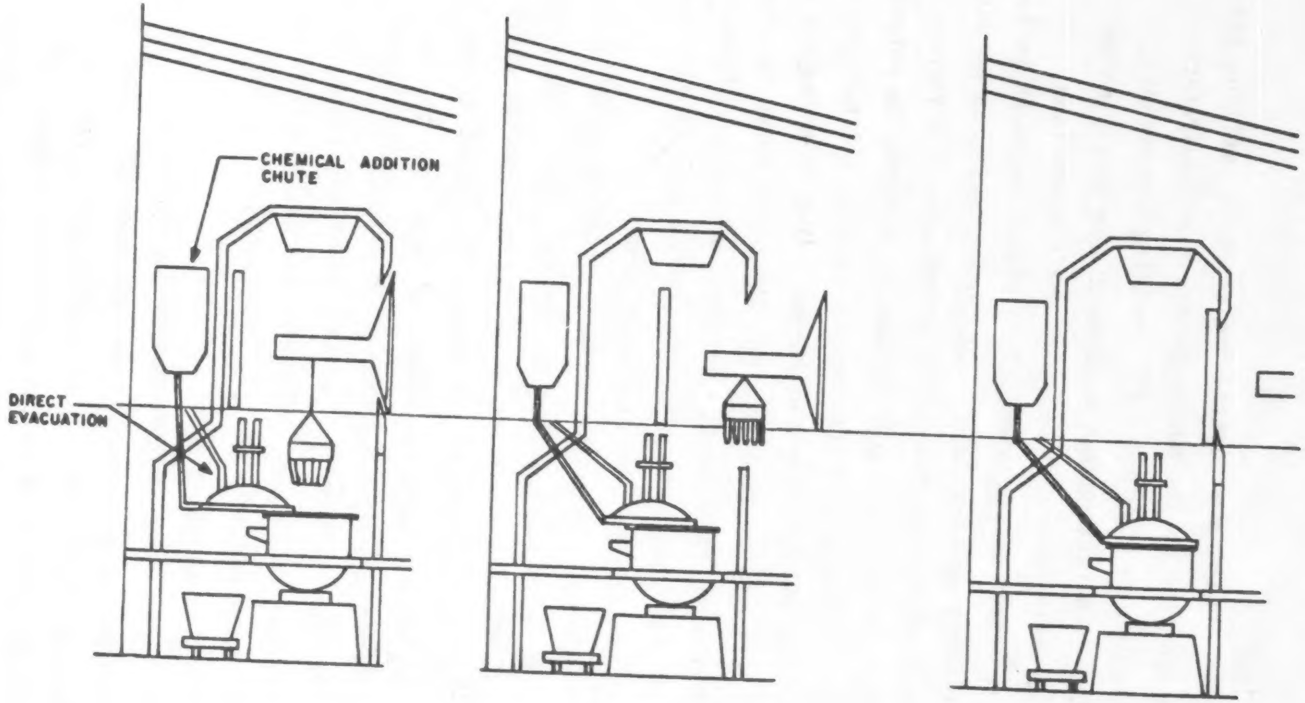

CHEMICAL ADDITION CHUTE
DIRECT EVACUATION

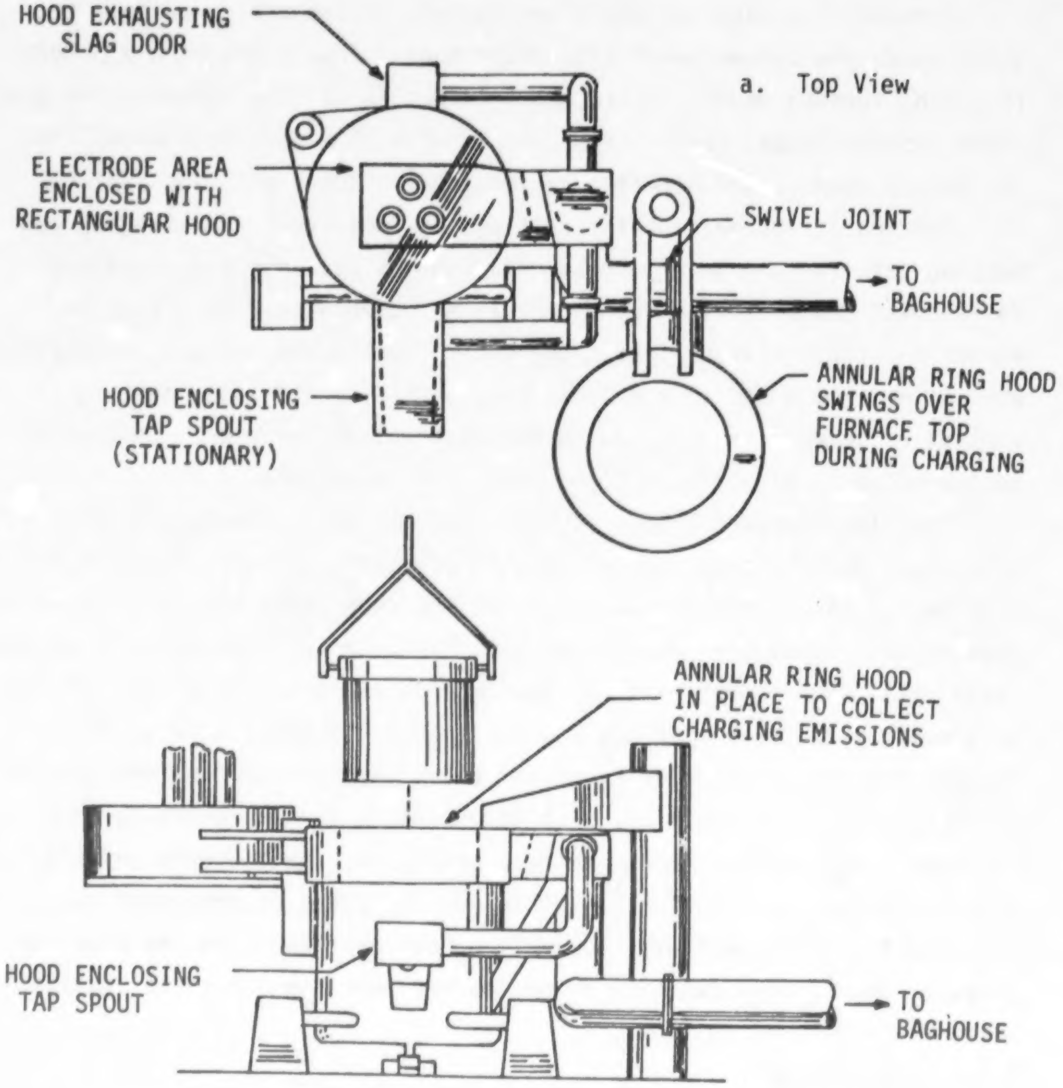
Figure 4-5. Krupp furnace -- sequence of events during charging.[24]

4.2.5 Close Capture Hood

The "close capture" concept for controlling charging, melting and tapping emissions, as supplied by the Hawley Division of Envirotech Corporation, is illustrated in Figure 4-6.[25] Melting and refining emissions are evacuated by a rectangular hood which completely encompasses the electrodes, unlike conventional side draft hoods (see Section 4.3.2) which are open on one side. This allows improved collection of emissions with minimum exhaust volumes. Capture of charging emissions is accomplished by an annular ring hood which encompasses the furnace rim during charging. The annular charging ring hood is designed to rotate onto the furnace during a charge and then rotate back to the furnace side during melting. Charging emissions are withdrawn radially through slots located on the inner side of the annular ring; the slots serve to increase capture velocity and improve emission collection. During the charging sequences, dampers in the exhaust ductwork divert the exhaust flow from the electrode hood to the annular charging ring hood.

Tapping emissions are collected by enclosing the tap spout with an inverted U-shaped hood which is exhausted to the main duct. When charging (or tapping), dampers divert most of the exhaust flow from the electrode hood to the charge (or tapping) hoods. A telescoping joint allows the electrode hoods to withdraw a moderate amount of fume from the furnace during tapping, supplementing the tapping hood exhaust. The tap hood only encloses the furnace tap spout and a portion of the ladle, as opposed to other designs (furnace enclosure, ladle pit enclosure) which enclose the entire ladle for more complete emission containment. A small, separate hood is also provided for the slag door.

The advantage of the close capture design is that control of charging and tapping are provided at an exhaust flow rate much less than for canopy hoods or furnace enclosures. This significantly reduces the quantity of exhaust gas delivered to the particulate control device, thus reducing costs of gas cleaning. Also, the close capture hoods are simpler and considerably less expensive to install than a furnace enclosure or canopy hood. The disadvantage is that complete control of charging and tapping may not always be provided because the charge/tap hoods do not completely enclose emission sources.


HOOD EXHAUSTING SLAG DOOR
ELECTRODE AREA ENCLOSED WITH RECTANGULAR HOOD
SWIVEL JOINT
TO BAGHOUSE
HOOD ENCLOSING TAP SPOUT (STATIONARY)
ANNULAR RING HOOD SWINGS OVER FURNACE TOP DURING CHARGING
ANNULAR RING HOOD IN PLACE TO COLLECT CHARGING EMISSIONS
HOOD ENCLOSING TAP SPOUT
TO BAGHOUSE

a. Top View

b. Side View

Figure 4-6. Hawley close capture hood.[25]

Exhaust flow rates of the close capture design are comparable to those used with conventional side draft hoods. For example, a 3.6-Mg/h (4 ton/h) furnace would require about 13.0 m^3/s (27,500 ft^3/min) for the close capture hoods, contrasting sharply with 65 m^3/s (138,000 ft^3/min) for canopy hoods. The manufacturer guarantees total emission capture efficiencies of 100 percent for melting and 80 percent for charging and tapping (of iron); however, these efficiencies have not been verified. No observations of the emission capture efficiency have been made as sufficient facilities utilizing the entire system are not yet in operation. When alloys are added to the ladle (e.g., steel foundries), tapping control efficiency is expected to be substantially reduced. Control of backcharging is also likely to be less than 80 percent.

The close capture design is applicable to most foundries where either the furnace area can be designed to accommodate the hoods or the hood design can be modified to adapt to the shop restrictions. The close capture design has been applied at several foundries, the majority of the installations being retrofit applications at existing foundries. At one particular steel foundry there was not enough clearance between the furnace and the transformer room wall to allow employment of the annular charging ring.[26] In this retrofit case, only a partial charging hood could be used, mounted to the furnace shell, to effect control of the charging emissions. Collection efficiency of charging emissions was observed to be substantially lower than that expected from the complete charging hood. Many existing foundries may have similar space restrictions which limit control options.

4.2.6 Clean Scrap

Charging clean scrap to an EAF substantially reduces charging emissions. When dirty scrap contacts a hot furnace, oil and other volatile impurities combust, releasing dense clouds of soot and smoke. Oily scrap can also cause premature roof failure around the electrode ports, damage dust evacuation hooding and ducts, and also clog or "blind" a fabric filter control device. Use of dirty, substandard scrap has been estimated to increase overall furnace emissions by up to 100 percent, although quantitative test data for charging emissions are generally not available.[27] Contact with several State and local air pollution agencies indicated that quite often foundries are required to use a clean scrap to control charging emissions.[28] For example, the Los Angeles County Air Pollution Control District issues operating permits to furnaces which use clean scrap as the method to control charging emissions. No visible emissions are detected at roof vents above the furnace during charging of clean scrap.

Dirty scrap can be cleaned prior to charging by preheaters or degreasing. Charge preheaters are standard equipment on induction furnaces for cleaning the charge, removing water, and avoiding the operating problems of charging dirty scrap. Few, if any, preheaters are used in EAF foundries in the United States although they have been used in other countries as a method for producing clean scrap for the reduction of charging emissions on EAF's in foundries and to increase melting capacity.

The most efficient preheater is the conveyor type which applies a fossil fuel flame to the scrap under an emission collection hood. The conveyor typically discharges clean, hot scrap to a charge bucket although a few systems have been designed to charge directly to the induction furnace.[29,30] Preheating in a special charge-preheat bucket has been used but does not result in uniform preheating. Ultra hot, intense flame jets must be directed into the scrap for certain periods to heat the entire charge, increasing the danger of overoxidation of thin pieces of scrap. Excessively oxidized scrap requires considerably more energy for melting.

Some preheaters are designed with a secondary combustion chamber which acts as an afterburner for controlling emissions from the preheater. One manfacturer of preheaters for induction furnaces reports that the air pollution codes of Los Angeles County are met by a local facility using this type of preheater.[27,29]

Preheaters used for induction furnaces reportedly reduce overall power costs for melting because the preheaters are more efficient in heating the metal, and costs for fossil fuel have traditionally been less than those for electricity. Net energy savings with preheaters have been quoted on the order of 300 MJ/Mg (75 kWh/ton) of metal, compared to normal melt requirements of about 1,980 MJ/Mg (500 kWh/ton).[29,30] Application of preheaters to EAF's will probably be severely limited by fuel shortages. Retrofitting existing EAF's with a conveyor-type preheater could require substantial reconstruction of scrap bins and scrap bucket handling systems.

A degreasing process to remove oil and dirt from the charge can also be used to reduce emissions caused by dirty scrap. Degreasing operations involve washing scrap in a tank with either a solvent or detergent and water. Excessive amounts of oil may be removed from turnings and other machining wastes by centrifuging, which typically reduces oil content to about 2 percent.

Degreasing has been traditionally used to remove oils from valuable scrap, such as brass, bronze, and copper, but is not usually applied to ferrous scrap at the foundry. Degreasing may be performed by scrap dealers. For example, motor blocks are often crushed and cleaned and then sold to the foundry.[1] Degreasing is not done extensively, however.

Problems with degreasing at foundries stem primarily from the solvent residues and air emissions of hydrocarbons from the solvents. Approximately 1 to 2.5 kg of solvent per Mg of charge cleaned (2 to 5 lb/ton) requires disposal when borings and turnings are the charge material. Of more importance, the mass of solvent emissions from the degreaser has been estimated to exceed emissions which would be generated by the charging of dirty scrap.[7] Thus, degreasing is not considered an environmentally acceptable option for reducing charging emissions from unclean scrap.

4.2.7 Briquetting Swarf

In many foundries, particularly steel foundries, up to 20 percent of each charge may be swarf, i.e., turnings and borings produced by the machining of castings. The swarf itself is readily oxidized upon charging and also contains oils from machining. Thus, charging swarf to the EAF results in greater generation of emissions, compared to charging of heavier scrap pieces. A briquetter can be used to compress the swarf into a more solid form which serves to minimize oxidation of metal during charging, thus reducing charging emissions. Briquetters are not common at foundries, and no data are available to quantitatively indicate the potential reduction in charging emissions.

4.2.8 The Brusa-Kemmetmueller Closed Charging System

The Brusa closed charging system, illustrated in Figure 4-7, has been operating on three steelmaking furnaces in Italy for several years.[31,32] Exhaust gases from the hot furnace are vented through a rotary kiln or drum. Charge material is fed continuously down through the kiln, into the furnace, and is preheated by furnace gases to about 1000°C (1830°F). Volatile matter entrained in the charge is thus oxidized and withdrawn at the top of the kiln along with the furnace exhaust gases.

This system has the advantages of heat recovery along with the containment of charging emissions in a fashion that allow for simple collection and ducting to a control device. This type of steelmaking is the continuous process, where charge material is continuously added. The Brusa and other conceptual designs for closed charging systems require small-sized scrap in order to pass through the enclosed system.

4.2.9 Hooded Charge Bucket

The hooded charge bucket, diagrammed in Figure 4-8, is designed to fit tightly over the top of the furnace during charging. Charging emissions pass upwards through the bucket and into an attached hood. Most of the emissions from charging would be collected and the exhaust volumes would be substantially lower than with a canopy collector. Some emissions would probably be combusted in the hood, and the hood and duct should be protected from heat and flame. Hooded charge buckets are commercially available, but none are known to be operating at present.[33]

A similar approach under study in Europe is the Marchand design, which utilizes a local, mobile hood that can be clamped above the charge bucket or suspended over the furnace by overhead crane, as shown in Figure 4-9. This system is very similar in function to a canopy but is smaller in size and can be lowered close to the furnace, minimizing the air volumes necessary to effectively capture the emissions. This variation of the hooded charge bucket concept has not been applied to foundry EAF's in this country.

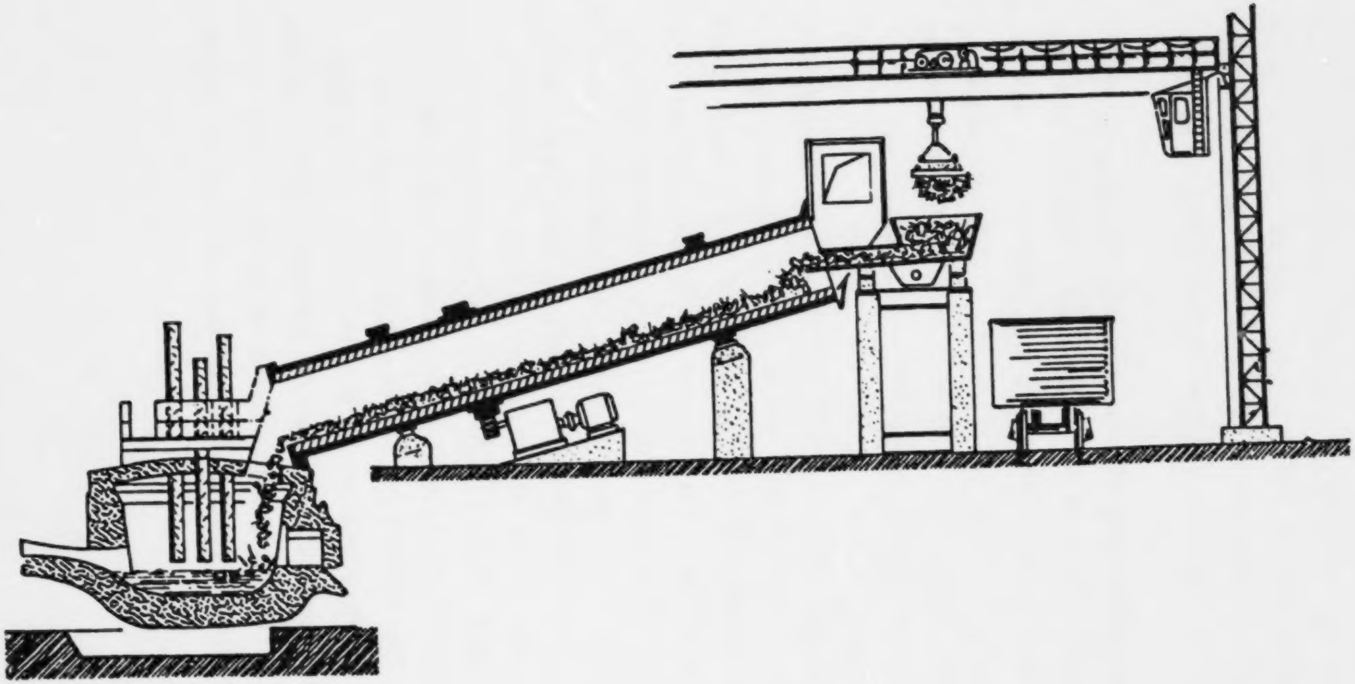


Figure 4-7. The Brusa charging and preheating system.[31]

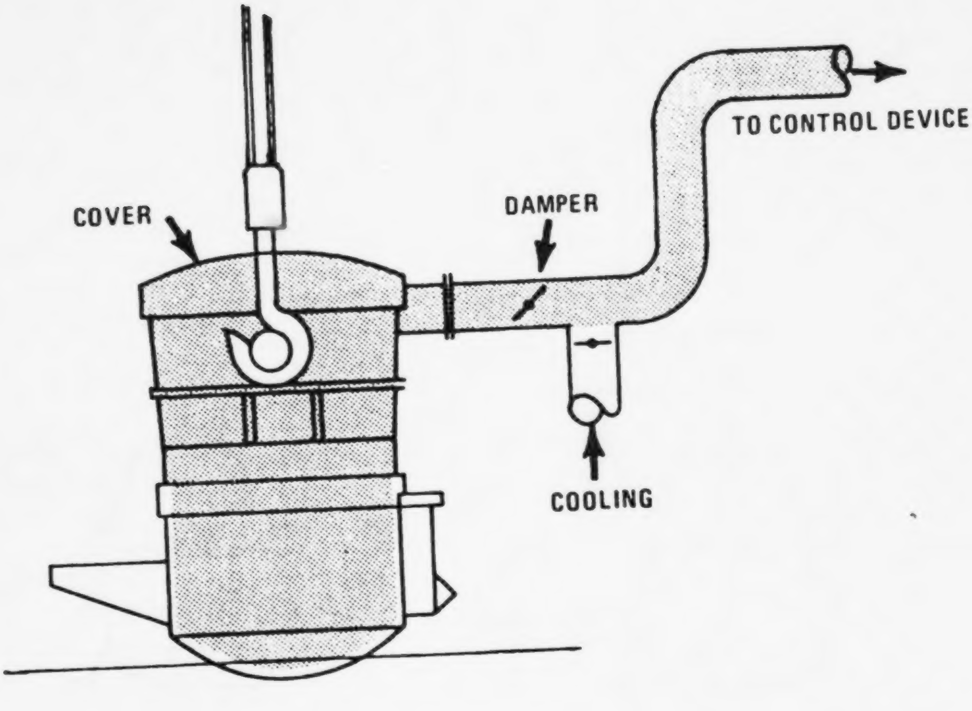

TO CONTROL DEVICE
COVER
DAMPER
COOLING

Figure 4-8. Hooded charge bucket.[1]

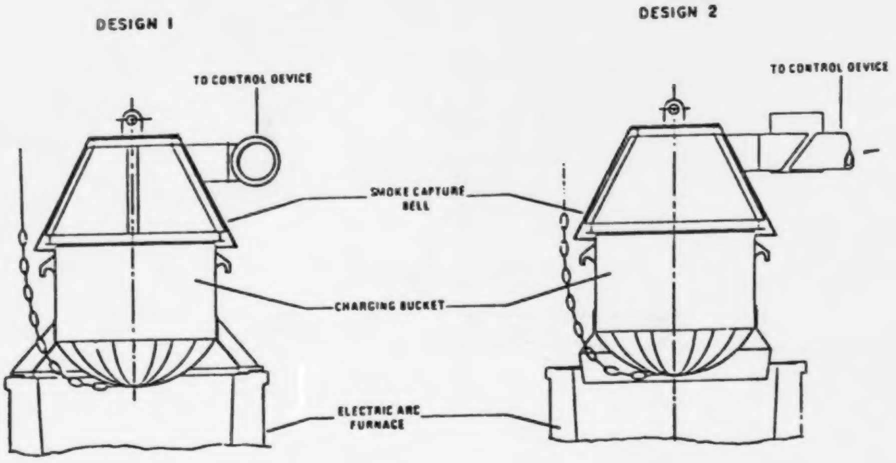

DESIGN 1
DESIGN 2
TO CONTROL DEVICE
TO CONTROL DEVICE
SMOKE CAPTURE BELL
CHARGING BUCKET
ELECTRIC ARC FURNACE

Figure 4-9. Marchand design for charging emission control.[1,6]

4.3 CONTROL OF MELTING AND REFINING EMISSIONS

Essentially all EAF's in iron and steel foundries collect furnace emissions during melting and refining with one of three basic systems:[1]

1. roof hoods;
2. side draft hoods; or
3. direct furnace evacuation.

This section describes typical components and configurations for each of the above basic control systems. Selection of the best system for control of melting and refining emissions depends on site specific variations, such as physical and structural constraints at the foundry and metallurgical requirements of the furnace.

When properly designed and maintained, each system can provide efficient capture of melting emissions and direct them to a gas cleaning device. There is normally a small leakage from the furnace or furnace evacuation systems. Some emissions inevitably escape through electrode holes and/or improperly sealed roof rings and slag doors, especially during initial meltdown, oxygen lancing, and when the slag door is opened (e.g., during bath sample extractions).

Melting and refining control systems are not designed to collect emissions from charging and tapping. The collection hoods or ducts are attached to the furnace roof and generally become inoperative during charging (when the roof is removed) and tapping (when the furnace tilts and disconnects from the main exhaust duct). Partial evacuation of the furnace during tapping may be accomplished through the use of telescoping ductwork connecting the furnace melting emission capture device and the main duct leading to the control device.

4.3.1 Roof Hood

A typical roof hood evacuation system is shown in Figure 4-10. The hood is mounted directly on the furnace roof and maintains an indraft through the annuli between the electrodes and the openings in the furnace roof. Extensions of the hood may also collect fumes from the pouring spout and slag or working door.

The full roof hood is the heaviest of the furnace evacuation systems. When retrofitting an EAF, allowances must be made for increased structural

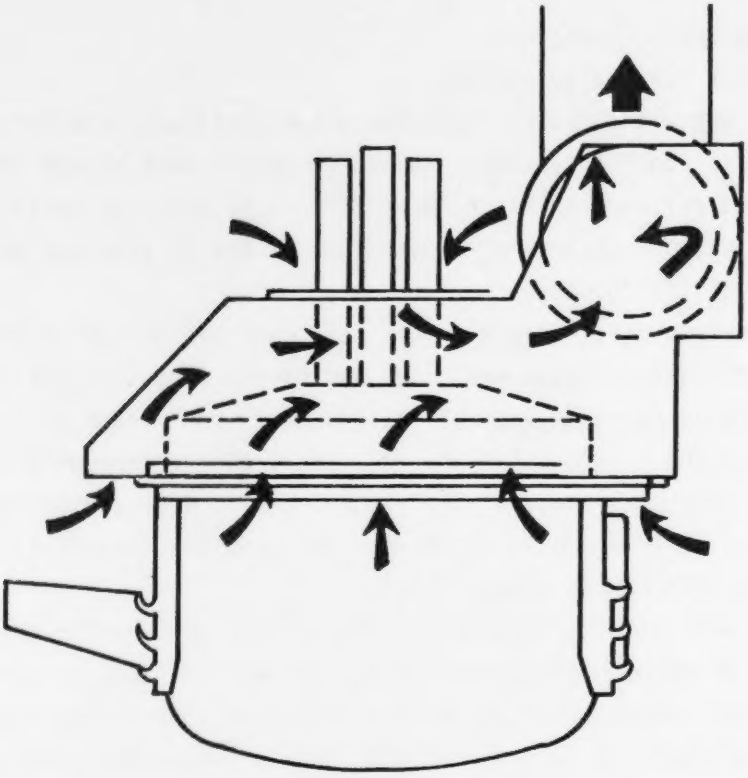


Figure 4-10. Roof hood.[1]

loads on the furnace roof, base, and the mechanisms which remove the furnace roof for charging.

The full roof hood can provide reliable collection of melting and refining emissions due to the hood's storage capacity to contain an instantaneous increase in emissions. As shown in Table 4-4, capture efficiency ranges from 95 to 100 percent for melting and refining emissions with 99 percent being a typical, maximum level encountered at foundries.[1] Exhaust flow rates typically range from 7.7 m^3/s (16,300 ft^3/min) for a 3.6-Mg/h (4-ton/h) furnace to about 30.0 m^3/s (63,600 ft^3/min) for a 22.7-Mg/h (25-ton/h) furnace.[1]

The roof hood has an advantage in that it muffles the noise of the furnace. A disadvantage is the difficulty of performing maintenance on the furnace roof. Hinged flaps mounted on the side or on the top of the hood can help alleviate this problem as well as allow for inspection of the furnace roof and the electrode ports.

A modification of the roof hood design, called a two-section hood, reduces access and weight problems which may be associated with the full roof hood. The two-section hood has separate subhoods, one located over the electrodes and the other located above the gap between the furnace shell and roof. Collection efficiency is slightly reduced over that of a full roof hood.

4.3.2 Side Draft Hood

The side draft hood shown in Figure 4-11 is mounted on the furnace roof. One side is open for the electrodes so that their travel is not restricted. Hoods may be mounted above the slagging door and pouring spout to connect back to the same exhaust duct as the side draft hood.

The hood collects the emissions after they have escaped from the furnace via the electrode holes. A substantial part of the furnace roof being left clear permits easy access for maintenance of the cooling glands and electrodes. The side draft hood does require larger exhaust volumes than a roof hood. The larger exhaust flow insures complete combustion of the carbon monoxide and reduces downstream exhaust temperatures. The side draft hood is simpler than a roof hood and places less weight on the furnace and furnace tilting mechanism. The furnace roof must seal tightly to the furnace shell to insure effective capture of

TABLE 4-4. TYPICAL EXHAUST FLOW RATES AND EMISSION CAPTURE EFFICIENCY OF MELTING CONTROL SYSTEMS

	Typical exhaust flow rate for model furnaces, in m^3/s (ft^3/min)			Emission capture efficiency (percent)	
	Furnace size				
	3.6 Mg/h (4 ton/h)	9.1 Mg/h (10 ton/h)	22.7 Mg/h (25 ton/h)	Range	Typical maximum
Side draft hood[a]	13.0 (27,500)	28.3 (60,000)	70.8 (150,000)	90-100[7]	99[7]
Roof hood[7]	7.7 (16,300)	11.9 (25,200)	30.0 (63,600)	95-100	99
Direct evacuation[7]	3.3 (7,000)	8.5 (18,000)	21.2 (45,000)	90-100	99
Furnace enclosure[b]	8.0 (17,000)	11.8 (25,000)	28.3 (60,000)	80-100[7]	99[7]
Close capture hood[7]	13.0 (27,500)	19.8 (42,000)	50.0 (106,000)	90-100	99

---

[a] Reference 7 for 3.6 Mg/h flow rate; Reference 34 for 9.1 and 22.7 Mg/h flow rates.
[b] Reference 9 for 3.6 and 9.1 Mg/h flow rates; Reference 7 for 22.7 Mg/h flow rate.

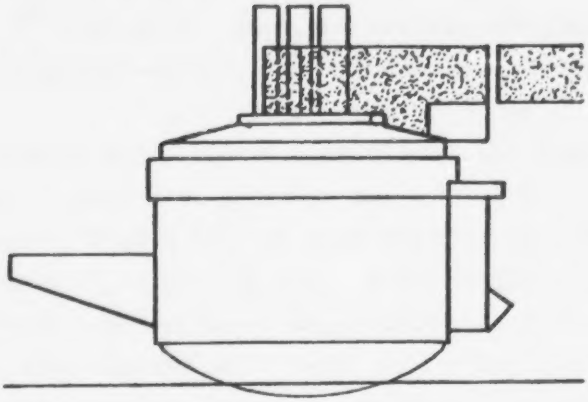


Figure 4-11. Side draft hood.[1]

melting emissions. Tight seals are not a requirement of roof hoods which enclose the entire furnace top.

Retrofitting an existing furnace with a side draft hood generally presents few problems. One large new foundry, however, reported severe deterioration of the fingerlike projections which collect emissions from electrode ports. The furnace was directly evacuated, with the side hood designed to catch fugitive emissions from the electrodes. Heavy stainless ductwork was eroded in a matter of weeks, and after many attempts at solving the problem, the company installed a roof hood.[35] This is not considered a common problem because many side draft hoods are operating quite satisfactorily on EAF's of all sizes.

Side draft hoods have the highest exhaust flow rate of the three devices for control of melting and refining emissions. Flow rates range from about 13.0 m^3/s (27,500 ft^3/min) for a 3.6-Mg/h (4-ton/h) furnace to about 70.8 m^3/s (150,000 ft^3/min) for a 22.7-Mg/h (25-ton/h) furnace.[1] These flow rates are typical of recent installations; older, less efficient side draft hoods used lower flow rates. The maximum emission capture efficiency expected from a side draft hood is 99 percent, ranging from 90 to about 100 percent.[7]

4.3.3 Direct Furnace Evacuation

Direct furnace evacuation (Figure 4-12), also known as fourth hole evacuation, requires another hole in the furnace roof or sidewall beyond the three required for electrodes. The exhaust gases are withdrawn from beneath the furnace roof. Mounted above this ventilation hole is an elbow which is connected via ductwork to the exhaust fan. The elbow must be designed to withstand the heat of the molten bath, i.e., water-cooled, high alloy stainless, or refractory-lined. The elbow is often not bolted to the exhaust duct; rather, a gap is maintained between the flange of the elbow and the off-take to permit aspiration of air which oxidizes the explosive, carbon-monoxide-rich stream to harmless carbon dioxide and reduces the temperature of the exhaust gases to protect the air pollution control equipment.

This evacuation system provides good emission control and minimizes both the space required on the furnace roof and the gas volume which must be withdrawn. Because the air flow necessary to capture emissions varies

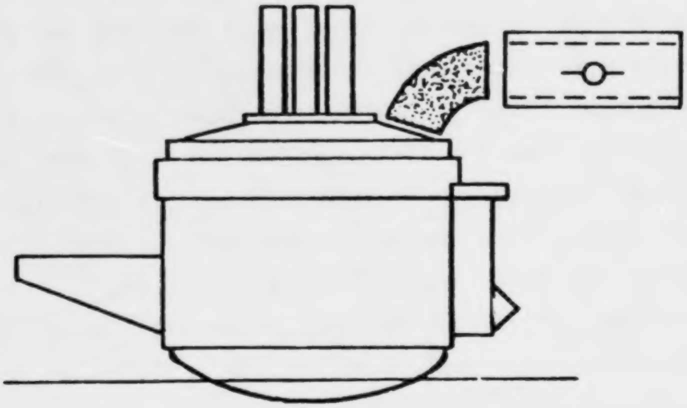


Figure 4-12. Direct evacuation through fourth hole.[1]

during different phases of the operating cycle, the amount of draft can be adjusted. Disadvantages are that the ingress of air to the furnace, although minimal, cools the slag, makes control of the temperature difficult, and reduces the carbon level in the melt through formation of carbon monoxide.

Direct evacuation systems are least applicable to EAF's which pour high carbon alloys and certain other specialty iron and steel. Direct evacuation is more common with steelmaking EAF's than with foundry furnaces; it is rarely used, if at all, with iron foundry EAF's. Direct furnace evacuation is not always a viable option for small steel furnaces because of (1) lack of space for the fourth hole and (2) pressure fluctuations in the furnace which are too rapid for automatic control of dampers in the exhaust duct. The direct evacuation system is easily retrofitted to an existing furnace. Problems reported concerning some EAF's which were retrofitted with direct evacuation include: additional weight on the furnace roof, excessive deterioration of shell refractories and roofs, water cooling problems, and clearance problems with roof rotation for charging.

Typically, exhaust flow rates for direct evacuation systems are 25 percent of those required for comparable fume control with side draft hoods. Table 4-4 shows flow rates ranging from 3.3 m^3/s (7,000 ft^3/min) for a 3.6-Mg/h (4-ton/h) furnace to about 21.2 m^3/s (45,000 ft^3/min) for a 22.7-Mg/h (25-ton/h) furnace.[7] Because the exhaust gas temperature is considerably greater with direct evacuation systems compared to side draft hoods, substantial dilution air is normally introduced to cool gases prior to the gas cleaning device. Emission capture efficiency is comparable to side draft hoods, ranging from 90 to 100 percent, with a typical maximum level of 99 percent for well-designed systems.

4.3.4 Other Systems

The furnace enclosure and close capture systems, described in Sections 4.2.4 and 4.2.5, respectively, also can control furnace emissions from melting and refining.

When viewing the furnace enclosure interior during melting, emissions generally appear to flow directly upwards in a column towards the exhaust duct near the top. The space around the inside perimeter of the enclosure is usually relatively free from emissions, as the rising column does not always fill the entire enclosure. Flames and emissions violently escape from the furnace electrode holes during melting. At times, however, the enclosure is full, or nearly full, of smoke and dust. This is the case during approximately the first 10 minutes of meltdown and periodically thereafter, particularly whenever power is restored to the electrodes. Emissions within the enclosure also increase during oxygen lancing.

Emissions escaping from the top of the enclosure during melting are generally of low to moderate volume, suggesting a capture efficiency of 80 to 95 percent. Emissions are highest during the first portion of the meltdown period and during oxygen lancing. The effect of the continually open rear enclosure door on enclosure emissions cannot be determined but is believed to have little effect.[10]

4.4 CONTROL OF TAPPING EMISSIONS

The EAF is tapped by raising the electrodes, tilting the entire furnace as much as 45 degrees and transferring the melt to a ladle through the pouring spout. Sparks and emissions of molten metal particles are ejected from the flowing metal. Alloys are usually added to the ladle, and the ensuing reaction may substantially increase tapping emissions, depending on the reactivity of the added alloys.

Some of the emission collection systems described in Section 4.2 for control of charging emissions, i.e., canopy hoods, building evacuation, bay evacuation, furnace enclosures, and close capture hoods, also collect tapping emissions. Tapping emissions can also be collected by enclosing and exhausting the ladle pit or by use of a tapping hood. Also, several designs for tapping hoods have been used at steelmaking furnaces.[1] Some of these tapping control systems are discussed below. No observations have been made of the close capture system to assess emission capture efficiency; thus, reference is made to the general discussion in Section 4.2.5.

4.4.1 ARMCo Tapping Pit Enclosure

ARMCo Incorporated was granted a U.S. patent for the tapping pit enclosure shown in Figure 4-13.[36] In this relatively simple design, the ladle is placed under the furnace in a tapping pit by conventional overhead

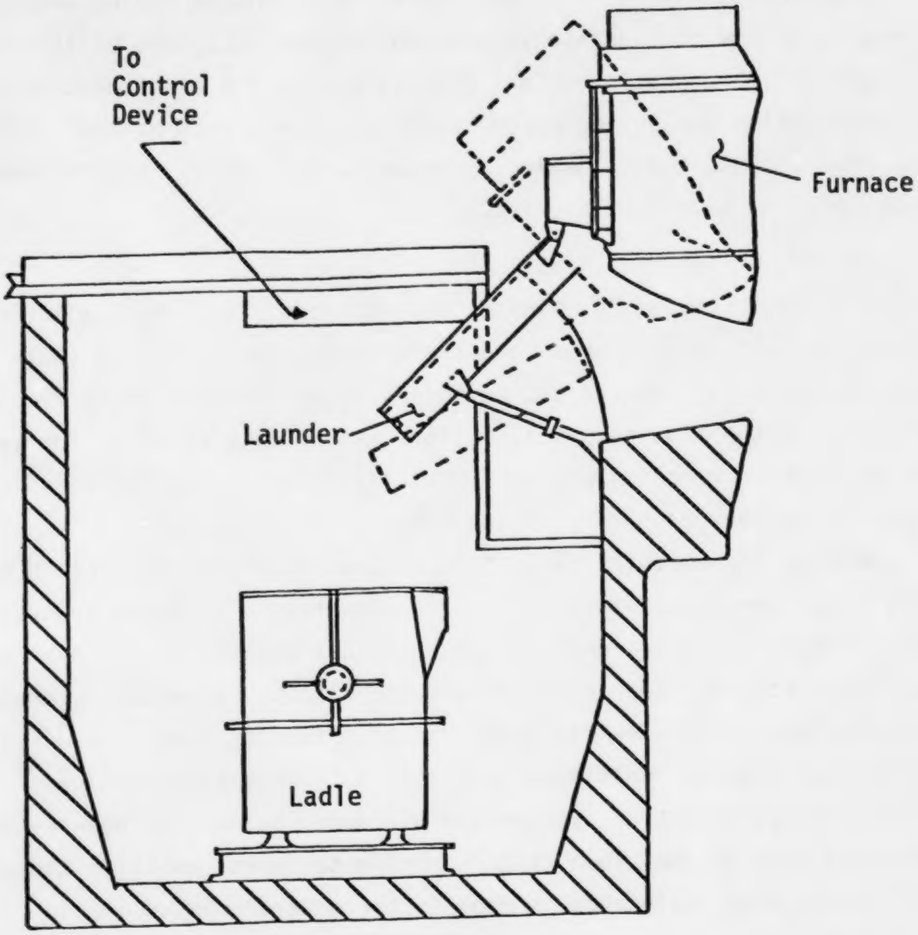

To
Control
Device
Furnace
Launder
Ladle

Figure 4-13. ARMCo Incorporated design for tapping pit enclosure.[36]

crane. A removable cover effectively seals the tapping pit after the crane is retracted. Molten metal flows from a short spout in the furnace to a launder, or chute, which extends through a side wall of the ladle pit. An exhaust duct near the top of the pit withdraws tapping emissions to a gas cleaning device.

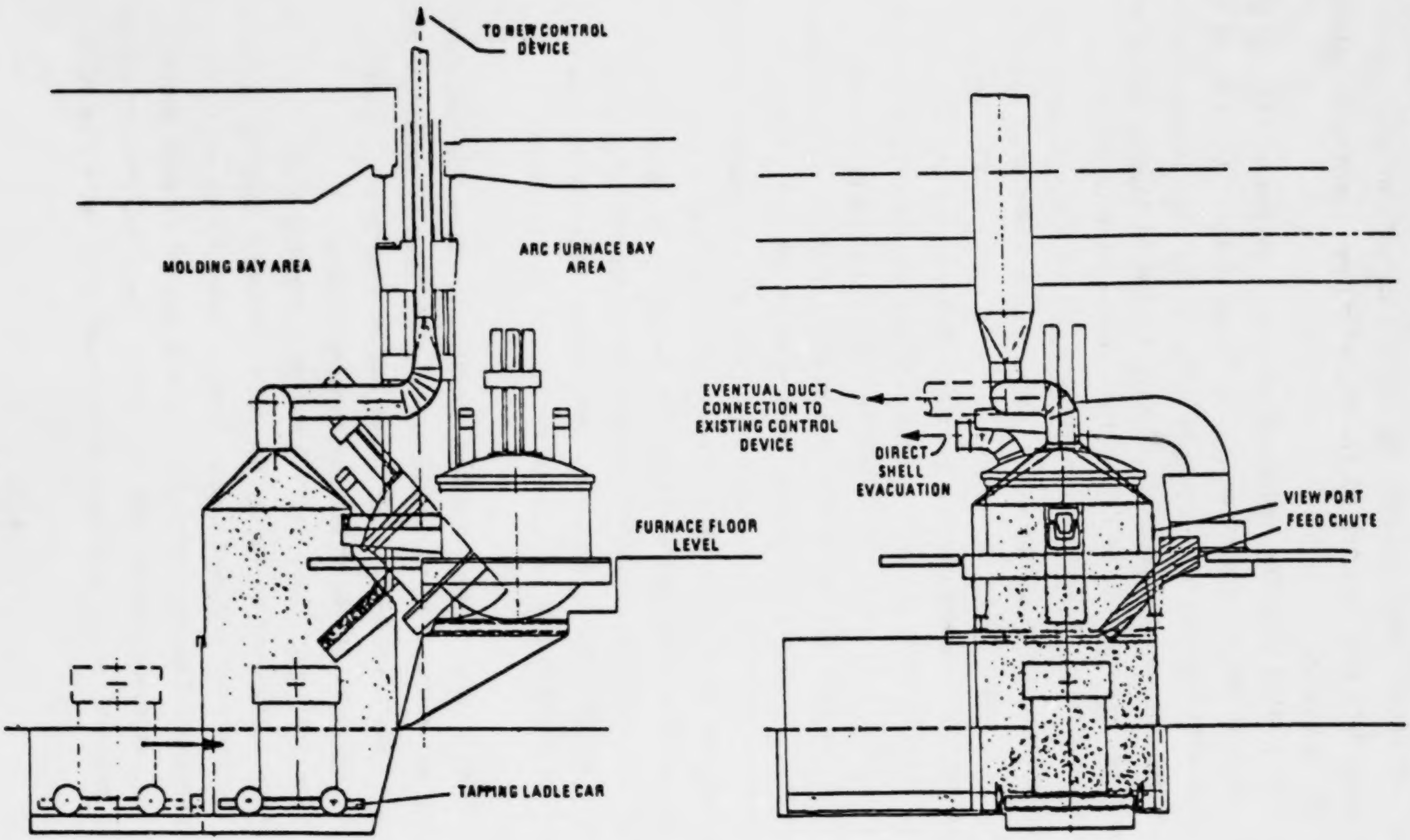
ARMCo Incorporated uses the ladle pit enclosure design at its Torrance, California, steel foundry. A portion (66 to 75 percent) of the exhaust flow which evacuates the furnace during melting is diverted to the ladle enclosure and provides a high capture velocity to remove tapping emissions. Exhaust flow rates are thus at or below those representative of side draft hoods (Table 4-1). The enclosure is designed to minimize openings through which emissions can escape and a high capture efficiency would be anticipated, i.e., about 80 to 95 percent.[11] This capture efficiency is based on observations and engineering judgment of personnel who visited the ARMCo facility in 1979. Only a low to moderate amount of alloying in the ladle is done at this facility. This is the only example of this type of emission capture system in the United States; thus, no determination could be made on its capture efficiency when greater amounts of ladle additions are made. Visible emission observations of the capture efficiency were made during the 1979 visit and are reported in Section 4.6.2.

While the ladle pit enclosure system can be easily designed into a new melt shop, retrofitting existing furnaces would depend largely on available space in the tapping area. At some shops there may be clearance problems when the tapping pit roof is retracted for ladle removal.

4.4.2 Hoods

Small, umbrella-shaped hoods located immediately above the ladle can collect tapping emissions from the ladle area. This type of tapping hood is sometimes used with steelmaking EAF's but not at foundries.[1] Such a design could be employed at foundries for tapping control.

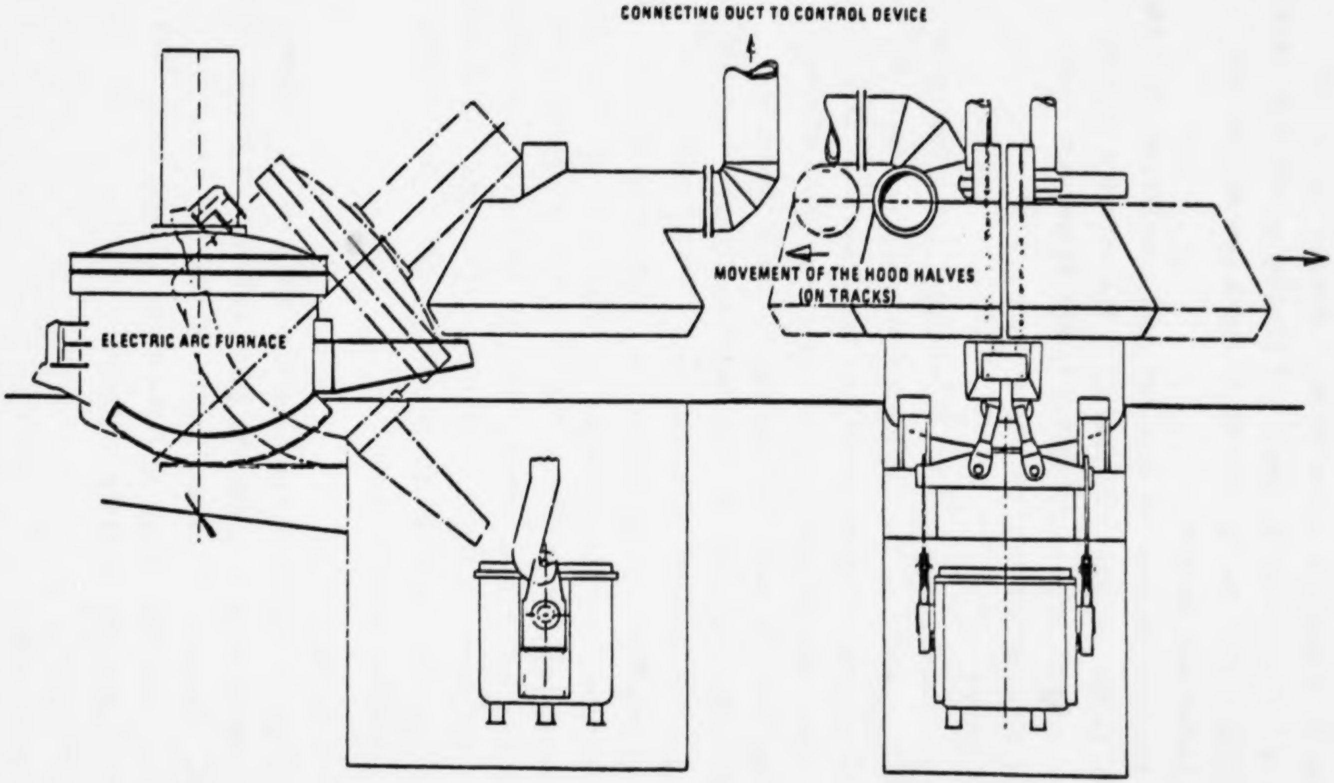
There are several approaches used to design a tapping hood. Figure 4-14 shows a proposed design by Marchand whereby a tapping ladle car receives the ladle by overhead crane, then is pushed into position underneath a permanent tapping enclosure. Such a system is most amenable to new foundries, as space limitations will often limit retrofit potential. Another design concept, shown in Figure 4-15, involves a ladle placed in


TO NEW CONTROL DEVICE
MOLDING BAY AREA
ARC FURNACE BAY AREA
FURNACE FLOOR LEVEL
TAPPING LADLE CAR
EVENTUAL DUCT CONNECTION TO EXISTING CONTROL DEVICE
DIRECT SHELL EVACUATION
VIEW PORT
FEED CHUTE

a. Side View

b. Front View

Figure 4-14. Proposed ladle car and ladle enclosure by Marchand.[1]


CONNECTING DUCT TO CONTROL DEVICE
MOVEMENT OF THE HOOD HALVES (ON TRACKS)
ELECTRIC ARC FURNACE

a. Side View

b. Front View

Figure 4-15. Mobile tapping hoods.[1]

a tapping pit. Further, as shown, a two-piece hood mounted on a track is placed over the ladle, around the crane cables. Another design for tapping hoods calls for removing the crane and placing a hood into position over the ladle. Flexible or easily matched ductwork connections are required for the latter two designs.

In general, the hood systems are somewhat more complicated than the enclosed ladle pit (ARMCo Incorporated design). The emission capture efficiency of this type of hood at foundries is not known, but high efficiencies would be expected for properly designed hoods.

4.4.3 Furnace Enclosure

The furnace enclosure was described in Section 4.2.4. During tapping, alloys are continously added to the ladle through a special chute extending through the enclosure side. Tapping emissions are drawn laterally into a rectangular side draft hood adjacent to the ladle top. Most of the emissions are drawn into the hood, because the entire 35 to 42 m^3/s (75,000 to 90,000 ft^3/min) exhaust is diverted from the enclosure top to the tap hood and capture velocity is quite high. Ten to twenty-five percent of tapping emissions escape collection, based on observation and engineering judgment, exiting the enclosure primarily through the alloy addition chute and through the enclosure top.[10] Emissions escaping the alloy addition chute usually dissipate by the time they reach the melt shop roof. Smoke observers at the Lone Star plant have read the opacity of emissions escaping the roof monitors as ranging from 0 to 40 percent during tapping, averaging about 8 percent.[19]

4.5 EXHAUST GAS CLEANING DEVICES

After evacuation of the emissions by one of the capture systems, a dust cleaning device is used to treat the gases before they are discharged to the atmosphere. Because of the small size of the dust particles generated by EAF's, only the following three types of dust collectors have been generally accepted as being suitable:

1. fabric filter;
2. wet scrubber; and
3. electrostatic precipitator (ESP).

Virtually all foundry EAF's in the United States use fabric filters. Fabric filters use considerably less power than scrubbers, are normally more efficient collectors of the fine particles characteristic of EAF emissions, are relatively insensitive to particle size variations in the gas stream, and also collect dust in a dry form which is readily disposable. Scrubbers produce wastewater which must be treated prior to recirculation to scrubbing units and require a high energy input to remove fine particles. Electrostatic precipitators have received only limited application to EAF's in the United States. Recent improvements in ESP collection efficiency may increase interest in using ESP's in this country, but installation and energy costs are high relative to fabric filters.

4.5.1 Fabric Filters

Fabric filters depend on a filter media to remove the dust from the gas stream. The devices are simple to operate and come in many designs, sizes, and shapes, differing primarily in the characteristics of the filter media (woven or felted glass or woven or felted synthetic fabrics) and the method of removing the dust from the fabric (reverse air pulse, mechanical shaking, reverse air flow, or combinations of these three).

Exhaust gas from the EAF contains fine particulates dispersed in a gas stream that changes considerably in temperature, dust concentration, size distribution, and volume during the various furnace phases. Fabric filter collectors (baghouses) are regarded as the most versatile and efficient device for cleaning these dust streams. Properly designed fabric filters can generally handle a tenfold variation in the inlet dust concentration without effecting the outlet dust concentration. Baghouses can be operated under positive or negative pressure and may be cleaned intermittently or automatically.

Positive pressure baghouses force exhaust gas through the bags using a fan placed between the collection duct and the baghouse. Maintenance and bag inspection is easier than with negative pressure units because the baghouse is not airtight and can be entered while in service, if the exhaust gas temperature is not too hot for personnel safety. Dirty gas drawn through each bag is filtered through the cloth, then vented to the atmosphere through louvers or vents along the top of each compartment.

New baghouses installed on EAF's tend to be the positive-pressure type because of lower capital costs and simple inspection procedures for detecting damaged bags.[1] With suction, or negative-pressure type baghouses, a fan on the clean air side of the baghouse pulls air through the bags. Bag compartments must be kept airtight, and thus inspection for defective bags requires the compartment to be taken off-line. Suction baghouses usually require less fan maintenance and less operating horsepower than the pressure type.

Fabric filter bags periodically become clogged with a dust cake and require cleaning to avoid excessive pressure loss. So-called intermittent systems are designed to run without cleaning until the end of a furnace heat, at which time flow stops and the bags can be manually shaken. Intermittent baghouses generally cost less and are easier to maintain than the automatic continuous service baghouse. The intermittent filter is most applicable to small, single furnace shops where there is adequate time between heats to manually clean the filter.

Automatic cleaning baghouses are much more common than intermittent systems as they are capable of continuous, unattended service, and precise control can be maintained over both pressure loss and particulate removal efficiency. Cleaning methods in common use are mechanical shaking, reversing the air flow, and pulse jet mechanisms, all of which dislodge collected particles from the bags to a hopper located underneath.

Current fabric filter technology has advanced to the extent that under certain conditions it may be possible to mount the unit directly on the foundry shop roof.[18] The filter inlet section would act as a canopy hood, eliminating the need for ductwork. Ground space would also be saved.

4.5.2 Wet Scrubber

Wet scrubbers moisten the gas stream to cool it and reduce the volume, then collect the dust-laden water droplets by inertial mechanisms. There are two basic scrubber types: wet impingement and venturi. In a wet impingement scrubber, furnace exhaust gas enters through the scrubber bottom, is cooled in a water spray zone, and passes through one or more impingement baffles which separate dust-laden water droplets from the gas stream. In a venturi scrubber, pressurized nozzles inject a water spray into the venturi section. Intense turbulence within the venturi constriction causes entrainment of particulates into the water droplets. The water-dust mixture is removed from the gas stream both within the venturi section itself and in a following cyclone separator. For either scrubber type, collection efficiency can approach 98 to 99 percent, but it is dependent on pressure drop (or energy expended) in the scrubbing (venturi) section.

Overseas, venturi scrubbers are commonly used with cupolas and steelmaking basic oxygen and electric arc furnaces, but there are no known venturi installations on iron or steel foundry EAF's in the United States.[8] Fabric filters are preferred over scrubbers for several reasons. High pressure venturi scrubbers are noisy, requiring elaborate muffler systems to prevent noise problems. Although installation costs and space requirements for the scrubber are somewhat lower, power costs are higher than those for fabric filters (especially for high efficiency scrubbers which operate at high pressure drop). Disposal of scrubber wastewater requires water treatment and/or water recirculation systems at the plant. Most importantly, wet scrubbers are generally not as efficient as baghouses for collecting the fine particles generated by the EAF.[8] Because of low capital costs and low space requirements, high-efficiency scrubbers may be a control option for existing EAF's in areas of the country with low power costs.

There is one commercially available, high energy scrubber which has been shown capable of meeting stringent concentration standards for an EAF. The Lone Star Steel scrubber achieves high removal efficiency on fine particles by means of steam injected at supersonic velocity in a mixing section. This unit was designed to operate with waste process heat from an integrated iron and steel mill. Where sufficient waste heat is available, this scrubber appears quite economical as compared to fabric filters. In a foundry with only an electric arc furnace, waste heat from the EAF alone would be sufficient to provide only a portion of the required energy.[19] An auxiliary fan would be necessary to provide the remainder; the scrubber thus would require about twice as much energy as a fabric filter system. Maintenance and capital costs are less for the scrubber at Lone Star Steel than for a baghouse. That scrubber may be an alternative to the fabric filter for efficient collection of the fine particulates from the EAF, if sufficient waste heat is available.

4.5.3 Electrostatic Precipitator

The electrostatic precipitator (ESP), another type of exhaust gas cleaning device, is often used in the control of particulates from basic oxygen steelmaking furnaces; however, no ESP's are currently in operation on domestic foundry EAF's.

The ESP operates by routing the gases through a high voltage field to impart an electrical charge to the dust particles and by subsequently trapping the particles on the oppositely charged collecting electrodes or plates by coulombic attraction forces. The dust particles are periodically removed from the collecting electrodes by water or mechanical vibration. On wet precipitators, dust is removed by flushing the collecting plates with water; on dry precipitators, dust is dislodged by "rapping" (i.e., shaking) the collecting plates.

Electrostatic precipitators have a relatively high collection efficiency for particles larger than several micrometers, but their successful operation is strongly dependent on the resistivity characteristics of the dust. Dusts from metallurgical processes must sometimes be wet with water to decrease resistivity to an acceptable range.[37] ESP collection efficiency has traditionally dropped markedly for smaller particles; however, developments in ESP technology have improved performance.

Installed costs and energy consumption for ESP's are somewhat greater than those for fabric filters. ESP's periodically require a certain amount of downtime for maintenance purposes. The space requirements of both precipitators and fabric collectors are almost the same.

A recent emission control system utilizing an ESP has been developed by a Japanese firm.[38] In this system, the ESP is mounted directly on the building roof with the inlet to the ESP being located at the roof crown. Fans are not used to move the exhaust gases through the ESP; rather, the upward thermal convection of the plume and the natural draft of the workshop are used to carry the plume into the ESP. Electric power consumption of the unit is, therefore, reported to be 2 to 5 percent of that required for baghouse systems. Although not in current usage in the

United States, the system is being used on EAF and basic oxygen furnace (BOF) shops and blast furnace cast houses in Japan.[39]

4.6 EMISSION SOURCE TEST DATA

4.6.1 Control Device Data

Virtually all foundry EAF's in the United States are controlled by fabric filters; thus, there is a general lack of emission source test data for scrubbers and ESP's. Particulate emissions from the EAF are predominately smaller than 20 μm (see Section 3.2) in size, and fabric filters are generally recognized as the most efficient collectors of fine particulates.[8]

Based on EPA test data presented in this section plus standard emission factors, properly designed and operated fabric filters can achieve effluent concentrations of 16 mg/dscm (0.007 gr/dscf)* or less. The technical literature reviewed confirms the above efficiency.[8,37,40] Fabric filter vendors also indicate that the above effluent concentration can be met.[41] Wet scrubbers can be designed for 98 to 99 percent removal of EAF dusts with effluent concentrations of about 46 mg/dscm (0.02 gr/dscf).[8] Other references indicate that scrubber performance on fine particle emissions from steel mills can be 97 percent for a scrubber with a 60-inch pressure drop.[40]

ESP efficiency on fine particle metallurgical emissions is reported in one reference as 95 percent.[40] Recent data reported for a large steelmaking EAF showed that effluent concentrations of 69 mg/dscm (0.03 gr/dscf) are obtainable with ESP's, and other data show that ESP's at steel mill EAF's are capable of achieving concentrations of 6 mg/dscm (0.0025 gr/dscf).[1,42]

The following subsections present data obtained by EPA on emissions from EAF fabric filter systems. The data are from field tests performed by EPA contractors on units selected as representing good control technology or submitted by industry or vendor representatives from performance tests.

---

*mg/dscm - milligrams per dry standard cubic meter.
gr/dscf - grains per dry standard cubic foot.

4.6.1.1 Iron Foundry Industry. EPA personnel obtained data from six iron foundry EAF's to establish typical levels of control of which fabric filters are capable. Figure 4-16 presents the results of measurements of particulate concentrations. Data for each plant are grouped in one vertical data bar; each data point represents a separate sample collected by traversing the sampling plane (unless otherwise noted). Data for Plants A, B, C, and D were obtained by EPA contractors during field tests while data for Plants E and F were submitted by industry or State agency representatives. A detailed summary of these test results is presented in Appendix C.

All furnaces were fitted with side draft hoods, except Plant C which had roof hoods for the capture of melting emissions. Figure 4-16 indicates average emissions ranging from 3.2 to 16.5 mg/dscm (0.0014 to 0.0072 gr/dscf) for five of the tested furnaces. However, Plant C showed average grain loadings of 58.9 mg/dscm (0.026 gr/dscf). At this foundry during the period of the tests, carbon black was injected into the molten metal via a pressure lance, and a manually cleaned baghouse was used. The use of the pressure lance is believed to be the cause of the increased emission rate. This foundry currently uses the pressure lance method of carbon injection only one percent of the time and would not use it again should a new foundry be built.[49] Other methods of carbon injection available to the industry are used more frequently, are less expensive, and are less polluting. Available information indicates that industry reliance on these alternate methods of carbon injection would not preclude the production of any metals now being produced. Thus, the data for Plant C will not be used as part of the data base.

The data for Plant E were provided by a State agency from its compliance test records. Due to discrepancies in the isokinetic sampling rate, sampling locations, and sample time vs. process conditions, the data may not be representative of results obtainable from tests adhering to the conditions of EPA Reference Method 5.[50] Therefore, the data will be given less weight in the data base. The data presented for Plant F were obtained during the ASTM Project Threshold program and represent 16 tests. As only slight modifications to EPA Reference Method 5 were

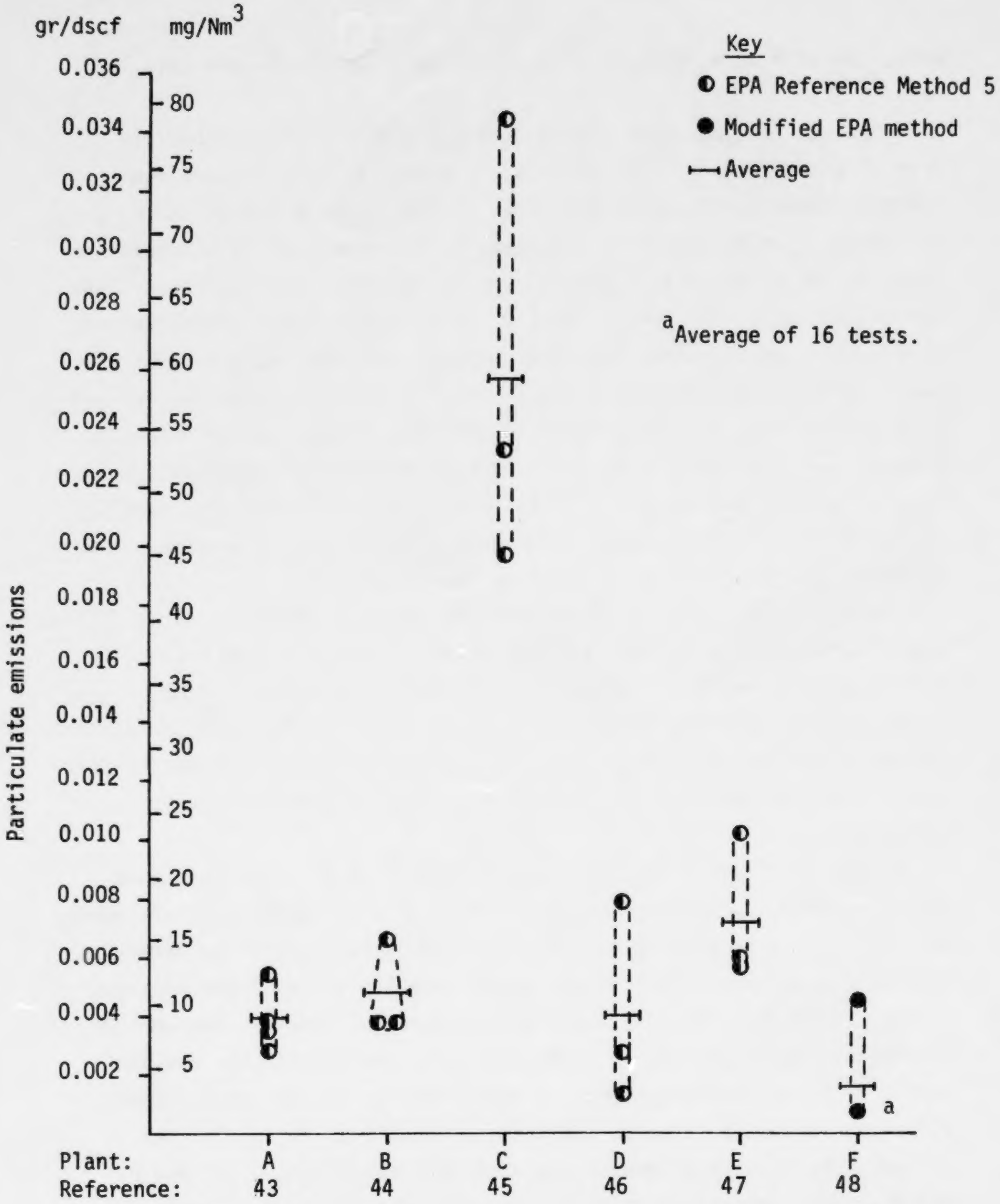


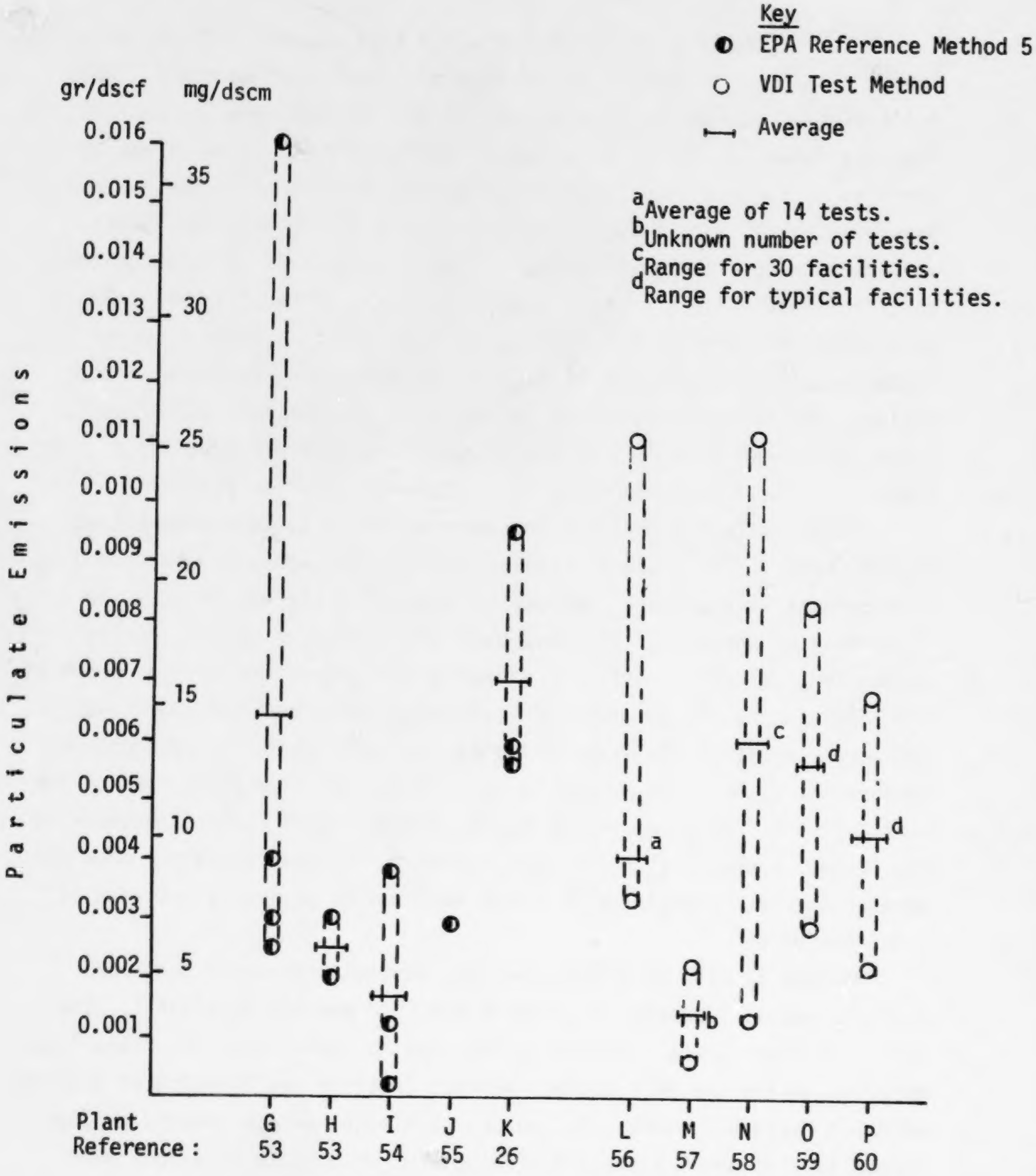
Figure 4-16. Summary of source test data for baghouses on EAF's producing iron.

made, the data were determined to be suitable for use in the data base.[51,52]

Opacity readings were obtained from the baghouse stack outlets of four of these furnaces (Plants A, B, C, and D) and the foundry roof monitors above the furnaces for three of the furnaces (Plants A, B, and D). Stack opacity (6-minute averages) ranged from 0 to 11.5 percent for three of the plants with 6-minute average readings of 5 percent or less for 90 percent of the time. Plant C, which had emission concentrations considerably greater than the other plants, had somewhat greater stack opacities with the 6-minute averages ranging up to 30.4 percent and being 5 percent or less only 70 percent of the time. Visual observations of foundry roof vents for three plants during melting indicated an opacity range (6-minute averages) from 0 to 10.4 percent, with average readings of 5 percent or less at least 93 percent of the time. A detailed summary of these opacity data is presented in Appendix C.

4.6.1.2 Steel Foundry Industry. Performance data for fabric filters operating on steel-producing EAF's are summarized in Figure 4-17. These data were obtained from industry representatives (Plants G, H, I, J, and K) and foreign contacts (Plants L, M, N, O, and P). The foreign data are presented for informative purposes only and will not be used in the data base. Detailed emission data for steel foundries are reported in Appendix C.

Data for Plants G, H, I, J, and K were obtained from acceptance tests on newly installed baghouses. Plants G and H use side draft hoods for the capture of melting emissions while Plants I and J use direct furnace evacuation. Plant K uses a modification of the close capture system. Since the data for these plants were not obtained through EPA contractor field testing, in most cases only the results are available. Little is known about the specific fabric filter or EAF installations, air/cloth ratios, or process and testing conditions during the test periods. Partial test reports are available for plants G, H, and J.[61,62] The data were determined to be suitable for use in the data base in support of other data.[63] The data for plant I will be given less weight in the data base because of discrepancies in the portion of the heat sampled for each run.



[a] Average of 14 tests.
[b] Unknown number of tests.
[c] Range for 30 facilities.
[d] Range for typical facilities.

Figure 4-17. Summary of source test data for baghouses on EAF's producing steel.

Data for plants L and M were obtained from acceptance tests on fabric filter installations in the Federal Republic of Germany. These facilities use direct furnace evacuation for melting emission capture. The data shown for Plants N, O, and P represent the typical levels of performance found on foundry or foundry size EAF fabric filter systems in Germany, France, and Italy, respectively, and do not represent tests performed on specific installations. Again, little is known about the specific installations or test conditions. All of the data presented were obtained using the VDI particulate test method. Based on prior tests conducted in the Federal Republic of Germany on municipal incinerators, EPA Reference Method 5 collected 30 percent more dust from the clean gas stream than did the VDI method. The data presented in Figure 4-17 have been corrected to incorporate this variation.

Visible emission observations were performed by EPA personnel at Plants G and I.[64,65] Stack opacity (6-minute averages) ranged from 0 to 21.9 percent with 6-minute average readings of 5 percent or less for 91 percent of the time. The maximum 6-minute average opacity during oxygen lancing was 2.7 percent. These observations were not performed at the same time as the particulate tests noted earlier. The opacity of the baghouse exhaust at steel foundries may be lower than at iron foundries because the carbon black added to iron is not completely absorbed by the melt. Five to forty percent of carbon added to iron furnaces escapes in the furnace exhaust gas, and these extremely fine particles may also pass through the baghouse.[7] Carbon black addition is generally not done at steel foundries.

Maximum opacity (6-minute average) reported from roof vents and monitors was 16.7 percent at Plant G and 10.0 percent at Plant I. The value for Plant G was observed during tapping, while that for Plant I was observed during the melt cycle. Neither facility had charging or tapping emission capture systems. The maximum 6-minute average opacity during oxygen lancing was 6.9 percent at Plant I. No visible emissions were observed during the melt cycle, including oxygen lancing, at the roof vents of Plant G. The 6-minute average opacity from the roof vents of Plant I was 5.0 percent or less, 89 percent of the time. The opacities are higher during tapping because of alloy addition to the ladle. Charging generated substantially less visible emissions at the shop roof while backcharging emission levels were between tapping and charging in magnitude for Plant G. Because of the quantity of alloys added to the ladle and the hotter tap temperature, fugitive emissions from a steel furnace are generally somewhat greater in magnitude than those from iron production.[1] The opacity data for steel foundries are detailed in Appendix C.

4.6.2 Capture Device Data

Visible emission observations using EPA Reference Methods 9 and 22 were made on the tapping pit enclosure.[66] Based on limited data, the emissions, as read 1.8 m (6 ft) above the pit enclosure, were visible only 30 percent of the time and had an opacity of 15 percent or less, both averaged over the entire tapping period. It should be noted that these values do not represent 6-minute averages as the readings (utilizing both reference methods) were made only from the start to the end of metal flow during tapping, a period of approximately 2.5 minutes. Due to the limited number of observations made, the data obtained are not sufficient for use in the data base.

As noted in Section 4.2.4, observations were made of emissions from the total enclosure system, but because of discrepancies in the data the results are not presented here nor are they to be used in the data base.

4.7 REFERENCES FOR CHAPTER 4

1. Fennelly, P. F. and P. D. Spawn. Air Pollutant Control Techniques for Electric Arc Furnaces in the Iron and Steel Foundry Industry. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. EPA-450/2-78-024. June 1978. 221 p.

2. Wood, R. M., Superintendent, Electric Furnace. Design Aspects of the Ford Steel Division Electric Furnace Shop. Ford Motor Company, Dearborn, Mich. Unpublished paper. 1976.

3. Telecon. Wright, A., Puget Sound Air Pollution Control Agency, with Spawn, P., GCA/Technology Division. March 24, 1977. Information on EAF's in Puget Sound area.

4. Kaercher, L. T. and J. D. Sensenbaugh. Air Pollution Control for an Electric Furnace Melt Shop. Iron and Steel Engineer. 51(5):47-51. May 1974.

5. Bintzer, W. W. and R. A. Malehorn. Air Curtains on Electric Furnaces at Lukens Steel Company. Iron and Steel Engineer. 53(7):53-55. July 1976.

6. Flux, J. H. Containment of Melting Shop Roof Emissions in Electric Arc Practice. Iron and Steelmaking (Quarterly). (3):121-133. 1974.

7. Memo and attachment from Georgieff, N. T., EPA, to Spawn, P., GCA/Technology Division. March 15, 1978. Information on flowrates.

8. Davis, J. A., E. E. Fletcher, R. L. Wenk, and A. R. Elsea. Screening Study on Cupolas and Electric Furnaces in Gray Iron Foundries. Final Report. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Contract No. 68-01-0611, Task No. 8. August 1975.

9. Letter from Bonistalli, R. J., Obenchain Calumet, to Maxwell, W. H., Midwest Research Institute. April 24, 1979. Response to EAF questionnaire.

10. Memo and attachments from Maxwell, W. H., Midwest Research Institute, to Crowder, J. U., EPA. July 11, 1979. Report of June 1979 plant visit to Lone Star Steel Company, Lone Star, Tex.

11. Memo and attachments from Maxwell, W. H., Midwest Research Institute, to Georgieff, N. T., EPA. July 5, 1979. Report of May 1979 plant visit to ARMCo Steel Corporation, National Supply Division, Torrance, Calif.

12. Memo from Maxwell, W. H., Midwest Research Institute, to EAF Files. March 21, 1980. Calculation of canopy hood related emissions.

13. Telecon. Hoenstine, J., Anderson Air Pollution Control Agency, with Spawn, P., GCA/Technology Division. March 21, 1977. Information on General Motors/Delco foundry.

14. Hansen, M. and H. Spitzer. Die Hallenentluftung in Huettenbetrieben. [Ventilation of Industrial Halls in Iron Metallurgical Plants.] Stahl und Eisen (Dusseldorf). 77(2):210. February 1957.

15. Memo from Maxwell, W. H., Midwest Research Institute, to EAF Files. March 21, 1980. Calculation of building evacuation related emissions.

16. Telecon. Aschinger, T., Wayne County Air Pollution Control Agency, with Spawn, P., GCA/Technology Division. March 22, 1977. Information on Ford Motor Company foundry.

17. Graf Spee, D. Ultra-Modern Electric Steelworks in Denmark. Engineering Digest. p. 21-25. November-December 1977.

18. Letter and attachments from Aston, W. T., Bahco Systems, Inc., to Georgieff, N. T., EPA. July 13, 1979. Response to inquiry on EAF emission control systems.

19. Memo from Spawn, P., GCA/Technology Division, to EAF file. September 14, 1977. 8 p. Report of September 1977 plant visit to Lone Star Steel Company, Lone Star, Tex.

20. Emission Test Report: Lone Star Steel Company, Lone Star, Texas. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 79-ELC-5. May 1979.

21. Telecon. Rosentreter, W., Otto H. Rosentreter Company, with Maxwell, W., Midwest Research Institute. July 2, 1979. Information on EAF total enclosure system.

22. Telecon. Baustian, K. F., Certified Alloy Products, Inc., with Maxwell, W. H., Midwest Research Institute. July 5, 1979. Information on EAF total enclosure system.

23. Letter and attachments from Baustian, K. F., Certified Alloy Products, Inc., to Cuffe, S. T., EPA. August 14, 1979. Response to Section 114 letter on EAF total enclosure.

24. Krupp Stahltechnik GmbH. Possibilities of Efficient and Low-Pollution Steelmaking in Electric Arc Furnaces. 299-070e1127805. Rheinhausen, Federal Republic of Germany. Undated. 6 p.

25. U.S. Patent No. 3,979,551. Arc Furnace Fumes Control System. Assigned to Hawley Manufacturing Corporation. Indianapolis, Ind. September 7, 1976.

26. Memo and attachments from Spawn, P., GCA/Technology Division, to EAF file. September 16, 1977. 16 p. Report of September 1977 plant visit to Hensley Industries, Inc., Dallas, Tex.

27. Coulter, R. S. Smoke, Dust, Fumes Closely Controlled in Electric Furnaces. The Iron Age. 173(1):107-110. January 14, 1954.

28. Memo from Spawn, P., GCA/Technology Division, to EAF File. May 9, 1977. Summary of telephone conversations with air pollution control agencies.

29. Telecon. Sharpless, R., Melting Systems, Inc., with Spawn, P., GCA/Technology Division. April 4, 1977. Information on scrap preheater.

30. Spencer, I. L. The Case for Conveyor Preheating. Foundry Management and Technology. 103(4):100-104. April 1975.

31. Brown, Boveri & Company, Ltd. The BBC/Brusa Process: A Contribution to the Economical Production of Arc-Furnace Steel. Publication No. CH-IW 511 090 E. Baden, Switzerland. Undated. 9 p.

32. U.S. Patent No. 3,645,515. Metallurgical Furnace Installation and Operating Method. Assigned to American Waagner-Biro Company, Inc., Pittsburgh, Pa. February 29, 1972.

33. Pennsylvania Engineering Corporation. Electric Arc Furnace Pollution Control. Pittsburgh. Undated. 16 p.

34. Letter and attachment from Oakland, D., Whiting Corporation, to Georgieff, N. T., EPA. February 9, 1976. Information on EAF evacuation flow rates.

35. Telecon. Andrews, W., Wayne County Air Pollution Control Agency, with Spawn, P., GCA/Technology Division. March 24, 1977. Information on foundries in Detroit area.

36. U.S. Patent No. 3,791,638. Metal Pouring Organization. Assigned to ARMCo Steel Corporation. Middletown, Ohio. February 12, 1974.

37. Watkins, E. R. and K. Darby. The Application of Electrostatic Precipitation to the Control of Fume in the Steel Industry. In: Fume Arrestment. Special Report 83. Report of the Proceedings of the Autumn General Meeting of The Iron and Steel Institute held at Church House, Great Smith Street SW1 on 26 and 27 November 1963. London, England, Williams Lea and Company Limited. 1964. p. 24-35.

38. Ito, S., S. Noso, M. Sakai, and K. Sakai. Roof-Mounted Electrostatic Precipitator. In: Symposium on the Transfer and Utilization of Particulate Control Technology. Vol. 1. Electrostatic Precipitators. U.S. Environmental Protection Agency. Publication No. EPA-600/2-79-044a. February 1979. p. 485-494.

39. Telecon. Tomita, S., Sumitomo Heavy Industries, Ltd., with Maxwell, W. H., Midwest Research Institute. May 4, 1979. Uses of roof-mounted ESP units.

40. Arthur D. Little, Inc. Steel and the Environment: A Cost Impact Analysis. A Report to the American Iron and Steel Institute. Report No. C-76482. May 1975. p. IV-2 to IV-6.

41. Memo from Spawn, P., GCA/Technology Division, to EAF File. May 9, 1977. Summary of telephone conversations with fabric filter vendors.

42. Whitehead, C. Design and Operating Experience with Electrostatic Precipitators on Electric Arc Furnaces. In: Proceedings: Particulate Collection Problems Using ESP's in the Metallurgical Industry. Feazel, C. E., (ed.). Research Triangle Park, N.C., U.S. Environmental Protection Agency. Publication No. EPA-600/2-77-208. October 1977. p. 23-39.

43. Air Pollution Emission Test: John Deere Tractor Works, Waterloo, Iowa. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-1. June 1974.

44. Source Sampling: John Deere Tractor Works, East Moline, Illinois. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 74-GFE-2. July 1974.

45. Air Pollution Emission Test: The Gleason Works, Rochester, New York. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-4. January 1975. 85 p.

46. Air Pollution Emission Test: The Paxton-Mitchell Plant, Omaha, Nebraska. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-3. February 1975. 173 p.

47. Letter and attachment from Hevey, L. A., State of Wisconsin Department of Natural Resources, to Georgieff, N. T., EPA. November 21, 1974. Report of source test at Beloit Corporation, Beloit, Wis.

48. Letter and attachment from Cropper, W. V., American Society for Testing and Materials, to Ajax, R. J., EPA. June 27, 1974. Submission of Draft D 2928 Report.

49. Telecon. Georgieff, N. T., EPA, to Bencus, H., The Gleason Works. February 20, 1980. Information on carbon injection via pressure lancing.

50. Memo from McCarley, J. E., Jr., EPA, to Georgieff, N. T., EPA. December 3, 1974. State of Wisconsin Test Report, Beloit Corporation, Beloit, Wisconsin.

51. Memo from Kelly, W. E., EPA, to Georgieff, N. T., EPA. July 19, 1974. Gray iron foundry data contained in ASTM D-2928 Report.

52. Memo from McCarley, J. E., Jr., EPA, to Georgieff, N. T., EPA. July 19, 1974. Gray iron foundry test ASTM D-2928 Report.

53. Letter from Wasem, J. W., American Steel Foundries, to Goodwin, D. R., EPA. June 18, 1976. Response to Section 114 letter on emission test results.

54. Allegheny County Health Department. Source Test of Baghouse on Steel Electric Arc Furnace at Bucyrus-Erie, Glassport, Pennsylvania. Pittsburgh, Pennsylvania. May 1975.

55. Telecon. Glenn, D., Buckeye Steel Casting Company, to Georgieff, N. T., EPA. September 18, 1976. Information on source tests at Buckeye Steel Casting Co.

56. Telecon. Welzel, K., Landesanstalt fur Immissions und Bodennutzungsschutz des Landes Nordrhein-Westfalen, to Georgieff, N. T., EPA. June 10, 1976. Information on source test at German steel EAF.

57. Letter and attachments from Welzel, K., Landesanstalt fur Immissions und Bodennutzungsschutz des Landes Nordrhein-Westfalen, to Georgieff, N. T., EPA. June 16, 1976. Information on source tests at German steel EAF's.

58. Letter from Rohrick, Thyssen Giesserei AG, to Georgieff, N. T., EPA. June 24, 1976. Information on source tests at German steel EAF's.

59. Letter from Berton, D., Air Industrie, to Georgieff, N. T., EPA. June 18, 1976. Information on French foundry EAF's.

60. Letter from Bozzetti, M. A., Air Industrie, S.P.A., to Georgieff, N. T., EPA. March 4, 1976. Information on Italian foundry EAF's.

61. Letter and attachments from Mitrick, S. F., American Steel Foundries, to Goodwin, D. R., EPA. October 26, 1976. Information on steel foundry EAF source tests.

62. Memo and attachments from Shepherd, J. L., Buckeye Steel Castings, to Georgieff, N. T., EPA. December 11, 1979. Information on steel foundry EAF source test.

63. Memo from McCarley, J. E., Jr., EPA, to Cuffe, S. T., EPA. December 27, 1979. Review of EAF foundry test reports.

64. Memo and attachments from Harrison, R. T. and Holzschuh, D., EPA, to McCarley, J. E., Jr., EPA. July 26, 1976. Trip report of visible emission observations of an EAF at American Steel Foundry.

65. Memo and attachments from Harrison, R. T., EPA, to McCarley, J. E., Jr., EPA. August 17, 1976. Trip to observe visible emissions of a steel foundry EAF.

66. Emission Test Report. Armco Steel, Torrance, California. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 79-ELC-6. May 1979.

5. MODIFICATION AND RECONSTRUCTION OF IRON AND STEEL FOUNDRIES

In accordance with Section 111 of the Clean Air Act, as amended in 1977, standards of performance shall be established for a list of categories of stationary sources which may cause or contribute significantly to air pollution. These standards apply to affected facilities, i.e., those identifiable pieces of process equipment or individual components which, taken together, would comprise a source that emits pollutants for which a standard has been promulgated and the construction, modification, or reconstruction of which commenced after proposal of the standard.

On December 16, 1975, EPA promulgated amendments (40 FR 58416) to the general provisions of 40 CFR Part 60, including clarification of the modification section and addition of a reconstruction section. Under these provisions, Sections 60.14 and 60.15 respectively, an "existing facility" may become subject to standards of performance if it is deemed to have been modified or reconstructed. An "existing facility" defined in Section 60.2(aa) is any apparatus of the type for which a standard of performance is promulgated and the construction, modification, or reconstruction of which was commenced before the date of proposal of that standard.

This chapter examines the provisions for modification and reconstruction and the applicability of these to electric arc furnaces (EAF's) in the iron and steel foundry industry, outlining conditions under which existing facilities could become subject to standards of performance. It is important to stress that standards of performance apply to affected facilities which, combined with existing and other facilities, comprise a stationary source. The addition of an affected facility to a stationary source through any mechanism (i.e., new construction, modification, or reconstruction) does not make the entire stationary source subject to standards of performance, but rather only the added affected facility.

5.1 PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 Modification

Section 60.14 defines modification, clarifies what constitutes an emission rate increase and the methods for determining the emission rate increase, and confirms the individuality of other emission sources within the stationary source.

Paragraph (e) of Section 60.14 lists certain physical or operational changes that will not be considered as modifications, irrespective of any change in the emission rate. These changes include:

1. routine maintenance, repair, and replacement;
2. an increase in the production rate not requiring a capital expenditure, as defined in Section 60.2(bb), or reqiuring a capital expenditure which does not exceed the guidelines provided in IRS Publication 534 (Tax Information on Depreciation) and 40 FR 58416 (Modification, Notification, and Reconstruction);
3. an increase in the hours of operation;
4. use of an alternative fuel or raw material if, prior to proposal of the standard, the existing facility was designed to accommodate that alternate fuel or raw material;
5. the addition or use of any system or device whose primary function is the reduction of air pollutants, except when an emission control system is removed or replaced by a system considered to be less environmentally beneficial; and
6. relocation or an ownership change.

5.1.2 Reconstruction

Section 60.15 defines reconstruction and provides for EPA determination of reconstruction if requested. The reconstruction provision is applicable only when the components of an existing facility are replaced to such an extent that the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost required to construct a comparable, entirely new facility and it is technologically and economically feasible for the facility to meet the applicable standard.

The purpose of this provision is to ensure that an owner or operator does not perpetuate an existing facility by replacing all but vestigial components (e.g., support structures, frames, housings), rather than totally replacing it, in order to avoid falling under the applicable standards of performance.

5.2 APPLICABILITY TO ELECTRIC ARC FURNACES IN THE IRON AND STEEL FOUNDRY INDUSTRY

For the purposes of this document, an electric arc furnace is considered to include the following components:

1. furnace shell, including roof;
2. tilting platform;
3. furnace superstructure (arms, columns, electrode positioning apparatus, roof elevating suspension beams);
4. roof lift and swing apparatus;
5. furnace tilting gear;
6. electric switch gear;
7. transformer;
8. secondary conductor system;
9. operator's control panel; and
10. dust handling system.

Except as noted in Section 5.1.1, any physical or operational change to any of these items that would result in an increase in the particulate emission rate (emissions per hour) to the atmosphere could be considered a modification. Replacement of any single item would not appear to constitute reconstruction although replacement or more than one item could be considered reconstruction, depending on the costs involved.

The enforcement division of the appropriate EPA regional office should be contacted whenever a source has questions regarding modification and reconstruction.

6. MODEL PLANTS AND REGULATORY ALTERNATIVES

6.1 INTRODUCTION

Due to the large number of plant configurations and process operating practices within the iron and steel foundry industry, it would be impractical to discuss each configuration with regard to emissions, environmental impact, and economics. For this reason, model plants will be used to describe the general types of facilities that are expected to be constructed, modified, or reconstructed within the industry in the future. These model plants do not necessarily represent any one specific facility but are meant to encompass the range of possibilities. The following sections of this chapter define both the foundry electric arc furnace model plants and the alternative methods to regulate emissions from processes and sources in plants related to the iron and steel foundry industry.

6.2 MODEL PLANTS

The production of iron and steel from foundries varies widely from plant to plant even though the basic operations are similar. Individual facility production is primarily determined by operating time and capacity. The plant capacity is generally dependent upon the ability to cast the molten metal rather than on the furnace capacity. Demand for the product and general economic conditions also affect production.

Three model plant configurations are presented in Tables 6-1 and 6-2 that reflect the conditions currently found within the industry and those expected to occur in the future. The production rates are based on the use of one of three EAF sizes: 3.6 Mg/h (4 tons/h), 9.1 Mg/h (10 tons/h), and 22.7 Mg/h (25 tons/h) (i.e., small, medium, and large furnaces, respectively). Table 6-1 presents data common to both iron and steel foundries relating to production, operating hours, process energy usage, and land area requirements. Table 6-2 presents data for gas temperature, exhaust

TABLE 6-1. MODEL PLANT PARAMETERS - COMMON

Model plant	Furnace size		EAF production		Operating time[a]	Land area		EAF process energy usage[b]		Furnace size designation
	Mg/h	tons/h	Mg/yr	tons/yr	h/yr	10^5 m^2	acres	10^{12} J/yr	10^6 kWh/yr	
1	3.6	4	5,760	6,400	1600	0.40	10	12.0	3.4	Small
2	9.1	10	17,500	19,200	1920	2.02	50	36.5	10.1	Medium
3	22.7	25	63,600	70,000	2800	4.05	100	133.0	36.8	Large

[a] Based on one 8-h shift/day: 200 d/yr small furnace, 240 d/yr medium furnace, and 350 d/yr large furnace.

[b] Based on 2,085 MJ/Mg (525 kWh/ton) of metal produced.

TABLE 6-2. MODEL PLANT PARAMETERS - SPECIFIC

Control system	Gas temp at fan	Exhaust air flow m^3/s (ft^3/min)			Emission control energy usage 10^{12} J/yr (10^6 kWh/yr)		
	°C (°F)	Small	Medium	Large	Small	Medium	Large
Side draft hood and baghouse	121 (250)	13.0 (27,500)	28.3 (60,000)	70.8 (150,000)	0.58 (0.16)	1.51 (0.42)	5.47 (1.52)
Direct furnace evacuation and baghouse	121 (250)	-- --	8.5 (18,000)	21.2 (45,000)	-- --	0.47 (0.13)	1.66 (0.46)

air flow, and emission control energy usage specific to the control systems expected to be used.

The model plants are assumed to be capable of casting either iron or steel. The exhaust gas characteristics are somewhat different for iron and steel and are described in detail in Section 3.2.3.6. The nature of the gas is such that ductwork and gas cleaning devices can be constructed of carbon steel. No emission control systems are required for process operation or are routinely used specifically for product recovery or safety. The raw materials used and products manufactured are typical of those discussed in Chapter 3. Water is used during EAF process operations for noncontact cooling but is generally recirculated with no disposal problems.

6.3 REGULATORY ALTERNATIVES

The three phases of EAF operation (charging, melting and refining in the furnace, and tapping) have been examined for standards development. These phases are discussed in Chapters 3 and 4. Approximately 90 percent of the EAF particulate emissions are generated during the melting and refining phase. Techniques to capture the emissions from melting and refining in the furnace and to remove the particulate from the captured gases have been demonstrated.

Various techniques are used at some plants to capture emissions from the charging and tapping phases of the EAF operation. These techniques include: canopy hoods, building evacuation systems, bay evacuation systems, total furnace enclosures, close capture systems, and tapping pit enclosures. Canopy hoods can capture emissions effectively under ideal conditions, but their performance is highly dependent on shop conditions. These hoods frequently achieve a relatively low capture efficiency because of the cross-drafts typically present in most shops. Also, because of the relatively large gas flow volumes that must be handled (up to 20 times the volume required for capturing emissions during melting and refining in the furnace), canopy hoods and any associated control device equipment require high energy and sufficient physical space. These requirements can lead to capital costs that are prohibitively high for the 3.6-Mg/h (4-ton/h) and 9.1-Mg/h (10-ton/h) furnace sizes.[1] In addition, net emissions to the atmosphere can increase if emissions generated at the power plant are also considered for canopy hood installations on a 3.6-Mg/h (4-ton/h) furnace.[2] The performance of bay evacuation systems, which are not used in domestic foundries, and building evacuation systems is not affected by cross-drafts. However, both of these systems may have higher energy requirements than the canopy hood. Thus, the same economic and net emission problems can result for these systems as for the canopy hood.[3] The performance of the only total EAF enclosure that was operational at the time of this study was characterized by EPA. The system did not perform adequately during charging operations. The emission capture effectiveness was low, possibly as a result of several factors, one of which is believed to be inadequate air flow through the system. No foundries utilizing the total close capture system were available for observation. A tapping pit enclosure is in use at one United States foundry. At this foundry, a relatively small amount of alloying is performed in the ladle, and the performance of the system under a normal, higher level of ladle alloying could not be determined. None of these techniques for the capture of charging and tapping emissions are considered to be demonstrated, at this time, for the full range of furnace operating conditions to be found in the industry. Therefore, the proposed standards apply only to the melting and refining phase of the EAF operation.

Two regulatory alternatives are presented for EAF operation in foundries. These alternatives are discussed in this section along with the control device systems that could be utilized to provide the required level of control. Table 6-3 presents the alternatives and the control systems along with the allowable emission limits for each alternative.

6.3.1. Regulatory Alternative No. 1

This alternative provides for no additional regulatory action by EPA. The regulatory baseline would be relied upon to control emissions from foundry EAF operations. As noted in Section 3.3, only particulate and visible emissions from the control device stack would be directly controlled by the typical State regulation applicable to foundries. This typical regulation takes the form of a process weight equation coupled with a specified visible emission limit. The trend of using side draft hoods and direct furnace evacuation as emission capture devices for melting and refining operations and fabric filters as emission control

TABLE 6-3. REGULATORY ALTERNATIVES AND CONTROL SYSTEM OPTIONS

Regulatory alternative/ control option	Total emissions kg/h (lb/h)[a]					
	Iron			Steel		
	Small	Medium	Large	Small	Medium	Large
Alternative 1 (baseline)						
Side draft hood and baghouse	7.2 (15.9)	15.1 (33.2)	31.9 (70.4)	7.6 (16.8)	-- --	-- --
Direct furnace evacuation and baghouse	-- --	-- --	-- --	-- --	16.0 (35.2)	34.2 (75.4)
Alternative 2 (melting and refining only)						
Side draft hood and baghouse	2.9 (6.4)	7.2 (15.9)	18.1 (39.8)	3.3 (7.3)	-- --	-- --
Direct furnace evacuation and baghouse	-- --	-- --	-- --	-- --	7.5 (16.6)	18.8 (41.5)
Emission reduction over baseline	4.3 (9.5)	7.9 (17.3)	13.8 (30.6)	4.3 (9.5)	8.5 (18.6)	15.4 (33.9)

[a] Includes fugitive emissions from Table 3-12.

systems would continue. A few new furnaces would be required to control fugitive emissions under state regulations, a trend which is already underway.

6.3.2 Regulatory Alternative No. 2

This alternative, similar to Alternative No. 1, also would require control of melting and refining (in the furnace) emissions only. However, the emission limit would be more stringent than that specified under the baseline condition for both particulate and visible emissions. Current fabric filter technology, combined with proper maintenance practices, can achieve lower emission limits than specified by State regulations. The use of the following systems would be expected to continue as suitable systems for this alternative:

1. side draft hood and fabric filter (iron and small steel foundries); or,
2. direct furnace evacuation and fabric filter (medium and large steel foundries).

6.4 REFERENCES FOR CHAPTER 6

1. Georgieff, N. T. and F. L. Bunyard. An Investigation of the Best Systems of Emission Reduction for Electric Arc Furnaces in the Gray Iron Foundry Industry. U.S. Environmental Protection Agency, Research Triangle Park, N.C. October 1976. Draft.

2. Memo from Maxwell, W., Midwest Research Institute, to EAF Files. March 21, 1980. Calculation of canopy hood related emissions.

3. Memo from Maxwell, W., Midwest Research Institute, to EAF Files. March 21, 1980. Calculations of building evacuation related emissions.

7.0 ENVIRONMENTAL IMPACT

The environmental impacts of the two regulatory alternatives presented in Chapter 6 are discussed below. One alternative requires an NSPS for electric arc furnace emissions during melting and refining; the other is the existing baseline control condition, which includes typical State regulations but no Federal regulations.

7.1 AIR POLLUTION IMPACT

To assess the impact of standards of performance on air pollution, the incremental reduction in air pollution beyond what would otherwise be achieved by the baseline case has been estimated. The baseline case assumes that the EAF's are subject to the process weight regulation (see Section 3.3):

$$E = 4.10\,P^{0.67} \qquad P \leq 30$$

$$E = 55.0\,P^{0.11} - 40 \qquad P > 30$$

where E = emission rate in lb/h

and P = process weight rate in tons/h.

7.1.1 National Particulate Emissions

Particulate emissions can be calculated using the following general equation:

$$E = \left(\sum_{i=1}^{3} n_i e_i H_i\right)/2{,}000$$

where E = particulate emissions, in tons/yr

i = index for plant size

n = number of furnaces (from Table 8-2)

e = emission rate per furnace (from Table 6-3), in lb/h per furnace

H = plant operating hours, in h/yr

2,000 = conversion factor from pounds to tons.

Table 7-1 presents the projected particulate emissions for each regulatory alternative. The increase in emissions from year 1 to year 5 is a result of an approximate 20 percent increase in production, which is described in Chapter 8.

As indicated in Table 7-1, the second regulatory alternative shows a 51 to 53 percent reduction in total (including fugitive) emissions over the baseline regulatory alternative for iron and steel foundries, respectively. The second alternative also provides approximately a 90 percent reduction over uncontrolled melting emissions.

7.1.2 Dispersion Analysis

Ground-level pollutant concentrations at specified locations downwind from three sizes of electric arc furnaces at iron and steel foundries have been estimated using atmospheric dispersion modeling.[1] A description of the model used and the results obtained are presented in the following subsections.

7.1.2.1 Model Description and Input Data. The model used in this dispersion analysis was the Industrial Source Complex (ISC) model.[2] ISC is an expanded version of the single source (CRSTER) model, modified to account for aerodynamic downwash and a larger number of sources and receptors. Concentration estimates were made using ISCST, the hour-by-hour version of ISC, for a network of receptors at various downwind distances from a model plant.

The ISC model requires input data on sources, receptors, and meteorology. These items are described in the following subsections.

7.1.2.1.1 Source data. Each source configuration and control alternative for EAF's was assumed to consist of one stack adjacent to a building. Each stack was treated in this analysis as a point source emitting particulates on a continuous basis. Fugitive emissions were also treated as a point source and assumed to be emitted near the building and at rooftop elevation. Each point source (stack and fugitive) was modeled separately in this analysis.

In this modeling, particulate emissions were considered as gaseous emissions, i.e., as though the particles would not settle out. Since 96 percent of the particles are smaller than 20 μm (Section 3.2.2.6), this assumption should not affect the concentration estimates.

TABLE 7-1. SUMMARY OF NATIONAL AIR POLLUTION IMPACT

Year after promulgation		1		2		3		4		5	
		Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel
Cumulative No. of new facilities of given size (mg/h)[a]	3.6	6	6	13	12	19	17	26	23	32	28
	9.1	3	3	6	7	9	11	12	14	15	18
	22.7	1	1	1	1	2	2	2	3	3	4
Nationwide uncontrolled emissions	Mg/yr	1,160	1,330	1,875	2,250	3,035	3,680	3,750	5,010	4,910	6,440
	(tons/yr)	(1,280)	(1,460)	(2,065)	(2,570)	(3,345)	(4,140)	(4,130)	(5,600)	(5,410)	(7,170)
Nationwide baseline emissions	Mg/yr	245	260	415	455	660	735	825	995	1,070	1,275
	(tons/yr)	(270)	(290)	(455)	(505)	(725)	(810)	(910)	(1,100)	(1,180)	(1,405)
Nationwide NSPS emissions[b]	Mg/yr	120	130	195	215	315	355	390	480	510	620
	(tons/yr)	(130)	(140)	(215)	(240)	(345)	(390)	(430)	(530)	(560)	(680)
Emissions reduction over baseline	Mg/yr	125	130	220	240	345	380	435	515	560	655
	(tons/yr)	(140)	(150)	(240)	(265)	(380)	(420)	(480)	(570)	(620)	(725)
	percent	51	51	53	53	52	52	53	52	52	51

---

[a] Facility size mix based on projected capacity increase (Table 8-4).

[b] Includes uncontrolled fugitive emissions.

The following data are required by the ISC model for each source:

1. emission height (m);
2. exit diameter (m);
3. exit velocity (m/s);
4. exit temperature (K); and
5. particulate emission rate (g/s).

Table 7-2 summarizes the source characteristics for each of the six model plants and the two regulatory alternatives.

Downwash effects are also considered in the ISC model. As indicated in Table 7-2, the source emission heights are comparable to the height of adjacent structures (i.e., 10 m). Emission gas streams, such as those modeled (with low emission heights, low exit velocities, and temperatures close to ambient), have small plume rise and thus low effective emission height. These sources will be affected by aerodynamic downwash, resulting in maximum concentration impacts close to the source.

7.1.2.1.2 Meteorological data. Meteorological data required by the ISC model include hourly values (for an entire year) of:

1. ambient temperature (K);
2. wind speed (m/s);
3. wind direction (nearest 10 degrees); and
4. stability class.

Daily morning and afternoon mixing height data are also required and interpolated internally in the ISC model to hourly values.

In this study, 1964 climatological data for Pittsburgh, Pennsylvania, and Oklahoma City, Oklahoma, were used for comparison purposes. Both data sets are reasonably consistent with meteorological conditions representing maximum or worst-case impact for short stacks. Maximum impacts occur when the wind direction persists within a narrow angular sector and moderate winds are predominant.

Pittsburgh is characterized by rolling-to-mountainous terrain, strong-to-moderate wind speeds, some persistent wind directions, neutral stability, and periods of calms. Oklahoma City, on the other hand, is located on relatively flat terrain. The climatological conditions are characterized by very persistent wind directions, moderate-to-high wind speeds, neutral stability, and few calms.

TABLE 7-2. SOURCE DATA FOR DISPERSION MODELING

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Exit diameter (m)	Emission height[a] (m)	Exit velocity (m/s)	Exit temperature (K)	Particulate emission rate (g/s)	
								Baseline	NSPS
1	Iron	3.6	Stack	1.0	11	16.6	395	1.31	0.113
			Fugitive	1.0[b]	10	18.0	310	0.693	0.693
2	Iron	9.1	Stack	1.4	11	18.4	395	2.42	0.24
			Fugitive	1.0[b]	10	18.0	310	1.76	1.76
3	Iron	22.7	Stack	2.1	16	20.4	395	4.46	0.60
			Fugitive	1.0[b]	10	18.0	310	4.41	4.41
4	Steel	3.6	Stack	1.0	11	16.6	395	1.31	0.114
			Fugitive	1.0[b]	10	18.0	310	0.806	0.806
5	Steel	9.1	Stack	0.8	11	16.9	395	2.42	0.07
			Fugitive	1.0[b]	10	18.0	310	2.02	2.02
6	Steel	22.7	Stack	1.2	16	18.7	395	4.46	0.19
			Fugitive	1.0[b]	10	18.0	310	5.04	5.04

[a] Building dimensions assumed to be 10 m (h) x 30 m (w) x 91 m (l) for all cases.

[b] Effective diameter.

Climatological data from 1964 were used because these data are fairly complete on an hour-by-hour basis. These data are considered to be meteorologically representative although no claim can be made in terms of climatological normalcy. The ISC model rejects days with questionable wind directions (which are often associated with light winds).

Finally, electric arc furnaces were assumed to be located in urban areas, i.e., including heat island effect.

7.1.2.1.3 Receptor data. The ISC model calculates concentration impacts for receptors at specified radial distances from the source. Receptors were located around each source at distances of 100, 300, 2,000, and 20,000 m at 10-degree intervals. It was assumed that the plant boundary was located 100 m from the nearest point source. A network of 216 other receptors was arranged around the plant at various distances. These latter receptors were located as a result of a preliminary source dispersion analysis which identified potential maximum impact locations.

All receptors were assumed to be at the same elevation as plant grade. The only terrain effects included in the modeling were those implicitly contained in the meteorological data (Pittsburgh, Pennsylvania and Oklahoma City, Oklahoma).

7.1.2.2 Discussion of Dispersion Calculations. Hourly concentration impacts from each stack are calculated by the ISC model. Concentrations are summed for each receptor and midnight-to-midnight averages are determined for each 24-hour period. Annual arithmetic mean concentrations are then calculated by the model for each receptor. Annual geometric means are obtained using the relationship between the arithmetic mean (m), the geometric mean (m_g), the standard geometric deviation (s_g), and by assuming the concentrations are lognormally distributed.[3] The relationship is:

$$m_g = \frac{m}{\exp\,(0.5\ \ln^2 s_g)}$$

The standard geometric deviations are estimated from area-specific monitors from quarterly and yearly air quality data statistics for 1977 and 1978.[4,5] Site-to-site and year-to-year s_g for particulates range from about 1.5 to

2.2. In this study, s_g was set equal to 1.8 for Oklahoma City and 1.72 for Pittsburgh.

Concentration estimates calculated by the ISC model are generally within a factor of 2 of measured ambient concentrations, especially for the uncomplicated conditions modeled here.

The modeled concentration impacts can be compared to the National Ambient Air Quality Standards (NAAQS):

Averaging time	Standard type	Particulate concentration ($\mu g/m^3$)
Annual geometric mean	Primary Secondary	75 60
24-hour maximum (not to be exceeded more than once per year)	Primary Secondary	260 150

7.1.2.3 Twenty-Four Hour Maximum Concentration Impacts. Maximum 24-hour (highest second-high) particulate concentration impacts are presented in Tables 7-3 through 7-6 for Oklahoma City and Pittsburgh and for the two regulatory alternatives. The highest second-high concentrations are specified for radial distances of 100, 300, 2,000, and 20,000 m. The maximum highest second-high concentration is indicated for each case; for all cases the maximum highest second-high occurred at 100 m downwind from the source. The concentration estimates for all cases are greater in Oklahoma City than in Pittsburgh.

The maximum 24-hour concentration impact (from the stack only) was 138 $\mu g/m^3$ for baseline conditions and 5.5 $\mu g/m^3$ for the second alternative. This shows a significant reduction in concentration impacts of the second alternative over the baseline alternative. Maximum concentration impacts from fugitive sources ranged from 27 to 332 $\mu g/m^3$ at 100 m downwind from the source.

Weighted-average, 24-hour maximum concentration impacts (including stack and fugitive impacts) from new sources are given in Table 7-7. The reduction in impact over baseline for the NSPS alternative was calculated to be in the range of 36 to 47 percent. The data in Table 7-7 were calculated based on the proportion of small to medium to large new furnaces in year 5 after NSPS promulgation, as indicated in Table 7-1.

TABLE 7-3. HIGHEST SECOND-HIGH 24-HOUR PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (OKLAHOMA CITY, OKLAHOMA - BASELINE)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Highest second-high particulate concentration impact (μg/m³)				
					At downwind distance			
				Maximum[a]	100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	55.4	55.4	21.1	3.59	0.23
			Fugitive	45.6	45.6	20.2	2.12	0.14
			Total	101	101	41.3	5.71	0.37
2	Iron	9.1	Stack	55.7	55.7	16.2	5.20	0.32
			Fugitive	116	116	51.2	5.39	0.35
			Total	172	172	67.4	10.6	0.67
3	Iron	22.7	Stack	10.3	10.3	5.66	4.38	0.43
			Fugitive	290	290	128	13.5	0.88
			Total	300	300	134	17.9	1.31
4	Steel	3.6	Stack	55.4	55.4	21.1	3.59	0.23
			Fugitive	53.0	53.0	23.5	2.47	0.16
			Total	108	108	44.6	6.06	0.39
5	Steel	9.1	Stack	138	138	58.3	6.82	0.47
			Fugitive	133	133	58.8	6.18	0.40
			Total	271	271	117	13.0	0.87
6	Steel	22.7	Stack	74.0	74.0	29.9	9.10	0.70
			Fugitive	332	332	147	15.4	1.00
			Total	406	406	177	24.5	1.70

[a] All maximum highest second-high occurred at the property boundary (100 m downwind from source).

TABLE 7-4. HIGHEST SECOND-HIGH 24-HOUR PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (OKLAHOMA CITY, OKLAHOMA - NSPS)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Highest second-high particulate concentration impact ($\mu g/m^3$)				
					At downwind distance			
				Maximum[a]	100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	4.78	4.78	1.82	0.31	0.02
			Fugitive	45.6	45.6	20.2	2.12	0.14
			Total	50.4	50.4	22.0	2.43	0.16
2	Iron	9.1	Stack	5.52	5.52	1.61	0.52	0.03
			Fugitive	116	116	51.2	5.38	0.35
			Total	122	122	52.8	5.90	0.38
3	Iron	22.7	Stack	1.38	1.38	0.76	0.59	0.06
			Fugitive	290	290	128	13.5	0.88
			Total	291	291	129	14.1	0.94
4	Steel	3.6	Stack	4.82	4.82	1.84	0.31	0.02
			Fugitive	53.0	53.0	23.5	2.47	0.16
			Total	57.8	57.8	25.3	2.78	0.18
5	Steel	9.1	Stack	3.98	3.98	1.69	0.20	0.01
			Fugitive	133	133	58.8	6.18	0.40
			Total	137	137	60.5	6.38	0.41
6	Steel	22.7	Stack	3.15	3.15	1.27	0.39	0.03
			Fugitive	332	332	147	15.4	1.00
			Total	335	335	148	15.8	1.03

[a] All maximum highest second-high occurred at the property boundary (100 m downwind from source).

TABLE 7-5. HIGHEST SECOND-HIGH 24-HOUR PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (PITTSBURGH, PENNSYLVANIA - BASELINE)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Highest second-high particulate concentration impact (μg/m^3)				
					At downwind distance			
				Maximum[a]	100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	39.8	39.8	13.1	3.26	0.23
			Fugitive	27.3	27.3	14.8	2.04	0.14
			Total	67.1	67.1	27.9	5.30	0.37
2	Iron	9.1	Stack	41.1	41.1	11.7	4.72	0.29
			Fugitive	69.3	69.3	37.7	5.17	0.37
			Total	110	110	49.4	9.89	0.66
3	Iron	22.7	Stack	9.37	9.37	5.08	2.72	0.33
			Fugitive	174	174	94.4	13.0	0.92
			Total	183	183	99.5	15.7	1.25
4	Steel	3.6	Stack	39.8	39.8	13.1	3.26	0.23
			Fugitive	31.8	31.8	17.2	2.37	0.17
			Total	71.6	71.6	30.3	5.63	0.40
5	Steel	9.1	Stack	97.0	97.0	41.9	6.44	0.49
			Fugitive	79.6	79.6	43.2	5.94	0.42
			Total	177	177	85.1	12.4	0.91
6	Steel	22.7	Stack	49.1	49.1	18.6	8.74	0.70
			Fugitive	199	199	108	14.8	1.05
			Total	248	248	127	23.5	1.75

[a] All maximum highest second-high occurred at the property boundary (100 m downwind from source)

TABLE 7-6. HIGHEST SECOND-HIGH 24-HOUR PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (PITTSBURGH, PENNSYLVANIA - NSPS)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Highest second-high particulate concentration impact (µg/m³)				
				Maximum[a]	At downwind distance			
					100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	3.44	3.44	1.13	0.28	0.02
			Fugitive	27.3	27.3	14.8	2.04	0.14
			Total	30.7	30.7	15.9	2.32	0.16
2	Iron	9.1	Stack	4.08	4.08	1.16	0.47	0.03
			Fugitive	69.3	69.3	37.7	5.17	0.37
			Total	73.4	73.4	38.9	5.64	0.40
3	Iron	22.7	Stack	1.26	1.26	0.68	0.37	0.05
			Fugitive	174	174	94.4	13.0	0.92
			Total	175	175	95.1	13.4	0.97
4	Steel	3.6	Stack	3.47	3.47	1.14	0.28	0.02
			Fugitive	31.8	31.8	17.2	2.37	0.17
			Total	35.3	35.3	18.2	2.65	0.19
5	Steel	9.1	Stack	2.81	2.81	1.21	0.19	0.01
			Fugitive	79.6	79.6	43.2	5.94	0.42
			Total	82.4	82.4	44.4	6.13	0.43
6	Steel	22.7	Stack	2.09	2.09	0.79	0.37	0.03
			Fugitive	199	199	108	14.8	1.05
			Total	201	201	109	15.2	1.08

[a] All maximum highest second-high occurred at the property boundary (100 m downwind from source).

TABLE 7-7. SUMMARY OF 24-HOUR CONCENTRATION IMPACTS FROM NEW SOURCES[a]

Location	Plant type	24-hour maximum weighted average concentration impact ($\mu g/m^3$) Baseline	24-hour maximum weighted average concentration impact ($\mu g/m^3$) NSPS for melting and refining only	Percent reduction in impact over baseline
Oklahoma City, Okla.	Iron	134	86	36
	Steel	191	108	43
Pittsburgh, Pa.	Iron	87	52	40
	Steel	124	66	47

[a] Stack and fugitive concentration impact; year 5 after NSPS promulgation.

7.1.2.4 Annual Geometric Mean Concentration Impacts. Maximum annual geometric mean concentrations are presented in Tables 7-8 through 7-11 for Oklahoma City and Pittsburgh and for the two regulatory alternatives. The maximum annual concentrations are specified for each radial distance (100, 300, 2,000, and 20,000 m). The maximum concentrations for each case (without regard for distance) are also specified. As in the 24-hour concentration results, the concentration impacts are greater in Oklahoma City than in Pittsburgh.

The maximum annual concentration impact (from the stack only) is 20.8 μg/m^3 for baseline conditions and 0.62 μg/m^3 for the second alternative. Maximum concentration impacts from fugitive sources range from 2.3 to 50 μg/m^3 at 100 m downwind from the source.

Weighted-average, maximum annual concentration impacts (including stack and fugitive impacts) from new sources are given in Table 7-12. The reduction in impact over baseline for the second alternative was calculated to be in the range of 30 to 43 percent. The data in Table 7-12 were calculated assuming the proportion of small to medium to large new furnaces in year 5 after NSPS promulgation given in Table 7-1.

7.2 WATER POLLUTION IMPACT

It is expected that fabric filters will continue to be the principal method of EAF emission control. Water sprays may be used to cool the gas stream before it enters a fabric filter or ESP, but when properly designed and operated, these water sprays produce no water discharge.[6] However, as noted in Section 4.5, wet scrubbers could be used to control particulate emissions from EAF's. The blowdown from the scrubbers would require treatment.

7.2.1 Volume of Wastewater

Since EAF's used in iron and steel foundries are similar to those used in the steelmaking industry, effluent volumes have been computed using the blowdown rates recommended by EPA for scrubbers utilized on EAF's in the steelmaking industry. The operation of a well-controlled system calls for 0.21-m^3 blowdown per Mg (50 gal/ton) of iron or steel manufactured.[7] Although many plants may now use larger quantities of water, this water

TABLE 7-8. MAXIMUM ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (OKLAHOMA CITY, OKLAHOMA - BASELINE)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Annual geometric mean concentration impact ($\mu g/m^3$)				
				Maximum (at distance, m)	At downwind distance			
					100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	7.10 (100)	7.10	2.95	0.67	0.03
			Fugitive	6.93 (100)	6.93	3.90	0.42	0.02
			Total	14.0 (100)	14.0	6.85	1.09	0.05
2	Iron	9.1	Stack	5.32 (100)	5.32	1.49	0.89	0.05
			Fugitive	17.6 (100)	17.6	9.91	1.07	0.04
			Total	22.9 (100)	22.9	11.4	1.96	0.09
3	Iron	22.7	Stack	0.59 (2,000)	0.50	0.37	0.59	0.06
			Fugitive	44.1 (100)	44.1	24.8	2.68	0.10
			Total	44.6 (100)	44.6	25.2	3.27	0.16
4	Steel	3.6	Stack	7.10 (100)	7.10	2.95	0.67	0.03
			Fugitive	8.06 (100)	8.06	4.53	0.49	0.02
			Total	15.2 (100)	15.2	7.48	1.16	0.05
5	Steel	9.1	Stack	20.8 (100)	20.8	9.56	1.37	0.05
			Fugitive	20.2 (100)	20.2	11.4	1.23	0.04
			Total	41.0 (100)	41.0	21.0	2.60	0.09
6	Steel	22.7	Stack	8.38 (100)	8.38	3.32	1.73	0.08
			Fugitive	50.4 (100)	50.4	28.4	3.06	0.11
			Total	58.8 (100)	58.8	31.7	4.79	0.19

TABLE 7-9. MAXIMUM ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (OKLAHOMA CITY, OKLAHOMA - NSPS)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Annual geometric mean concentration impact ($\mu g/m^3$)				
				Maximum	At downwind distance			
				(at distance, m)	100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	0.61 (100)	0.61	0.25	0.06	<0.01
			Fugitive	6.93 (100)	6.93	3.90	0.42	0.02
			Total	7.54 (100)	7.54	4.15	0.48	<0.03
2	Iron	9.1	Stack	0.53 (100)	0.53	0.15	0.09	<0.01
			Fugitive	17.6 (100)	17.6	9.91	1.07	0.04
			Total	18.1 (100)	18.1	10.1	1.16	<0.05
3	Iron	22.7	Stack	0.08 (2,000)	0.07	0.05	0.08	<0.01
			Fugitive	44.1 (100)	44.1	24.8	2.68	0.10
			Total	44.2 (100)	44.2	24.8	2.76	<0.11
4	Steel	3.6	Stack	0.62 (100)	0.62	0.26	0.06	<0.01
			Fugitive	8.06 (100)	8.06	4.53	0.49	0.02
			Total	8.68 (100)	8.68	4.79	0.55	<0.03
5	Steel	9.1	Stack	0.60 (100)	0.60	0.28	0.04	<0.01
			Fugitive	20.2 (100)	20.2	11.4	1.23	0.04
			Total	20.8 (100)	20.8	11.7	1.27	<0.05
6	Steel	22.7	Stack	0.36 (100)	0.36	0.14	0.07	<0.01
			Fugitive	50.4 (100)	50.4	28.4	3.06	0.11
			Total	50.8 (100)	50.8	28.5	3.13	<0.12

TABLE 7-10. MAXIMUM ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (PITTSBURGH, PENNSYLVANIA - BASELINE)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Annual geometric mean concentration impact ($\mu g/m^3$)				
				Maximum (at distance, m)	At downwind distance			
					100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	2.44 (100)	2.44	1.05	0.32	0.02
			Fugitive	2.27 (100)	2.27	1.56	0.23	0.01
			Total	4.71 (100)	4.71	2.61	0.55	0.03
2	Iron	9.1	Stack	1.77 (100)	1.77	0.52	0.36	0.02
			Fugitive	5.76 (100)	5.76	3.96	0.59	0.02
			Total	7.53 (100)	7.53	4.48	0.95	0.04
3	Iron	22.7	Stack	0.22 (2,000)	0.18	0.12	0.22	0.03
			Fugitive	14.4 (100)	14.4	9.92	1.48	0.06
			Total	14.6 (100)	14.6	10.0	1.70	0.09
4	Steel	3.6	Stack	2.44 (100)	2.44	1.05	0.32	0.02
			Fugitive	2.64 (100)	2.64	1.81	0.27	0.01
			Total	5.08 (100)	5.08	2.86	0.59	0.03
5	Steel	9.1	Stack	7.43 (100)	7.43	3.68	0.71	0.03
			Fugitive	6.61 (100)	6.61	4.55	0.68	0.03
			Total	14.0 (100)	14.0	8.23	1.39	0.06
6	Steel	22.7	Stack	2.77 (100)	2.77	1.08	0.76	0.04
			Fugitive	16.5 (100)	16.5	11.3	1.69	0.07
			Total	19.3 (100)	19.3	12.4	2.45	0.11

TABLE 7-11. MAXIMUM ANNUAL GEOMETRIC MEAN PARTICULATE CONCENTRATION IMPACTS FROM ELECTRIC ARC FURNACES (PITTSBURGH, PENNSYLVANIA - NSPS)

Case	Plant type	Plant size (Mg/h)	Stack or fugitive	Annual geometric mean concentration impact (μg/m^3)				
				Maximum	At downwind distance			
				(at distance, m)	100 m	300 m	2,000 m	20,000 m
1	Iron	3.6	Stack	0.21 (100)	0.21	0.09	0.03	<0.01
			Fugitive	2.27 (100)	2.27	1.56	0.23	0.01
			Total	2.49 (100)	2.49	1.65	0.26	<0.02
2	Iron	9.1	Stack	0.18 (100)	0.18	0.05	0.04	<0.01
			Fugitive	5.76 (100)	5.76	3.96	0.59	0.02
			Total	5.94 (100)	5.94	4.01	0.63	<0.03
3	Iron	22.7	Stack	0.03 (2,000)	0.02	0.02	0.03	<0.01
			Fugitive	14.4 (100)	14.4	9.92	1.48	0.06
			Total	14.4 (100)	14.4	9.94	1.51	<0.07
4	Steel	3.6	Stack	0.21 (100)	0.21	0.09	0.03	<0.01
			Fugitive	2.64 (100)	2.64	1.81	0.27	0.01
			Total	2.85 (100)	2.85	1.90	0.30	<0.02
5	Steel	9.1	Stack	0.21 (100)	0.21	0.11	0.02	<0.01
			Fugitive	6.61 (100)	6.61	4.55	0.68	0.03
			Total	6.82 (100)	6.82	4.66	0.70	<0.04
6	Steel	22.7	Stack	0.12 (100)	0.12	0.05	0.03	<0.01
			Fugitive	16.5 (100)	16.5	11.3	1.69	0.07
			Total	16.6 (100)	16.6	11.4	1.72	<0.08

TABLE 7-12. SUMMARY OF ANNUAL GEOMETRIC MEAN CONCENTRATION IMPACTS FROM NEW SOURCES[a]

Location	Plant type	24-hour maximum weighted average concentration impact ($\mu g/m^3$) Baseline	24-hour maximum weighted average concentration impact ($\mu g/m^3$) NSPS for melting and refining only	Percent reduction in impact over baseline
Oklahoma City, Okla.	Iron	18.5	12.9	30
	Steel	28.0	16.4	41
Pittsburgh, Pa.	Iron	6.15	4.24	31
	Steel	9.43	5.38	43

[a] Stack and fugitive concentration impact; year 5 after NSPS promulgation.

discharge rate is considered proper operation by EPA and has been used to set standards for the steelmaking industry.[8]

7.2.2 Quality of Wastewater

Blowdown could contain both dissolved and suspended pollutants. Potential pollutants in the wastewater are listed in Table 7-13. These pollutants will be present as suspended particulate matter and as dissolved trace materials.

Currently, the effluent limitations promulgated by EPA for effluent from scrubbers on steelmaking EAF's apply only to total suspended solids and pH when application of the best practicable control technology is to be utilized.[9] The scrubber effluent from an EAF in an iron or steel foundry should be very similar. Of the potential pollutants listed in Table 7-13, only oil and grease, pH, suspended solids, and total oxygen demand (TOD) might need treatment.

7.2.2.1 pH. The pH of the scrubber effluent should be similar for iron and steel EAF scrubbers because the EAF's utilize similar raw materials. It is not anticipated that treatment for pH will be required.

7.2.2.2 Total Oxygen Demand (TOD). Oil and grease, and hence total organic carbon (TOC), are potentially higher for the iron and steel foundry EAF than the steelmaking EAF. The charge in an iron or steel foundry EAF may contain borings, turnings, and chips which are contaminated with cutting oils. Partial combustion of these oils produces soot and vapor which may dissolve and increase the total oxygen demand of the wastewater. No data are available which indicate the biochemical oxygen demand (BOD) or the TOD in a scrubber effluent from an EAF. Even if 1 percent of the total carbon content in the particulate is soluble, the total carbon content of the wastewater will be from 1.8 to 25 mg/ℓ, which would not require treatment.

The presence of oils and grease in the scrap is deleterious to electric arc and other types of furnaces and especially to the air pollution control equipment. To avoid problems, foundries are imposing increasingly stringent specifications for the amount of oil permissible in scrap. This has resulted in more pretreatment and cleaning of scrap by the suppliers. Therefore, the likelihood of oil being found in scrubber effluent from EAF's is diminishing.

TABLE 7-13. CATEGORIES OF POLLUTANTS WHICH MIGHT BE FOUND IN AN EAF SCRUBBER SYSTEM EFFLUENT[8]

Acidity
Alkalinity
Carbon and its compounds
Color
Fluorides
"Hardness"
Heat (temperatures above ambient)
Iron and compounds
Lead and compounds
Mercury and compounds
Nitrogen and compounds
Oil and grease
Phosphorus compounds
Silica
Sulfur compounds
Solids (suspended and dissolved)
Total oxygen demand

If an EAF were consistently charged with very oily scrap, such as turnings from machining operations, then the scrubber effluent might contain enough oily matter to require the use of an oil skimmer as part of the water treatment facility.

7.2.2.3 Total Suspended Solids (TSS). Total suspended solids from the scrubber effluent would be generated as shown in Table 7-14. These data are based on the emission limits provided in Table 6-3. Normal scrubber efficiencies (i.e., in the range of 97-99 percent particulate removal) could produce greater amounts of suspended solids than those indicated.

7.2.3 Water Treatment

The blowdown from scrubbers can be treated for removal of suspended solids using a classifier followed by a clarifier and/or a magnetic flocculator. (Figure 7-1 is a simple schematic diagram of a proposed treatment system.) This system is recommended by EPA for use on the scrubber effluent from steelmaking EAF's and is capable of reducing the suspended solids to 50 mg/ℓ, a removal efficiency of 99.8 percent.[7] The blowdown is sent to a classifier from which solids are continuously removed using a moving trowel or screw conveyor. The solids are trucked to a landfill for disposal. The liquid effluent from the classifier is sent to a clarifier that utilizes polyelectrolytes to promote chemical coagulation. Sludge is drawn from the bottom of the clarification tank and is vacuum filtered. The dewatered sludge is disposed of with the classifier solids, and the water is recycled into the clarifier. If further solids reduction is required, the water effluent from the clarifier can be discharged to a magnetic flocculation tank. This step is not likely to be required when chemical coagulation is utilized.

7.2.4 Conclusions

A wet scrubber on an EAF would produce about 0.21 m^3/Mg (50 gal/ton) of wastewater if operated prudently. Available data indicate that this wastewater would have a pH of approximately 8.0 and a TOC content of less than 25 mg/ℓ.

Treatment to remove suspended solids would be required before the wastewater could be discharged to a receiving stream. Water treatment

TABLE 7-14. SUMMARY OF WET SCRUBBER SOLIDS COLLECTION

Year after promulgation		1		2		3		4		5	
		Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel
Cumulative No. of new facilities of given size (mg/h)[a]	3.6	6	6	13	12	19	17	26	23	32	28
	9.1	3	3	6	7	9	11	12	14	15	18
	22.7	1	1	1	1	2	2	2	3	3	4
Nationwide baseline suspended solids to scrubber water[b]	Mg/yr	915	1,070	1,460	1,795	2,375	2,945	2,925	4,015	3,840	5,165
	(tons/yr)	(1,010)	(1,170)	(1,610)	(2,065)	(2,620)	(3,330)	(3,220)	(4,500)	(4,230)	(5,765)
Nationwide NSPS suspended solids to scrubber water[b]	Mg/yr	1,040	1,200	1,680	2,035	2,720	3,325	3,360	4,530	4,400	5,820
	(tons/yr)	(1,150)	(1,320)	(1,850)	(2,330)	(3,000)	(3,750)	(3,700)	(5,070)	(4,850)	(6,490)
Suspended solids increase over baseline[b]	Mg/yr	125	130	220	240	345	380	435	515	560	655
	(tons/yr)	(140)	(150)	(240)	(265)	(380)	(420)	(480)	(570)	(620)	(725)
	percent	14	12	15	13	15	13	15	13	15	13

[a] Facility size mix based on projected capacity increase (Table 8-4).

[b] Worst-case assumption (not expected to occur) that all facilities controlled by wet scrubber.

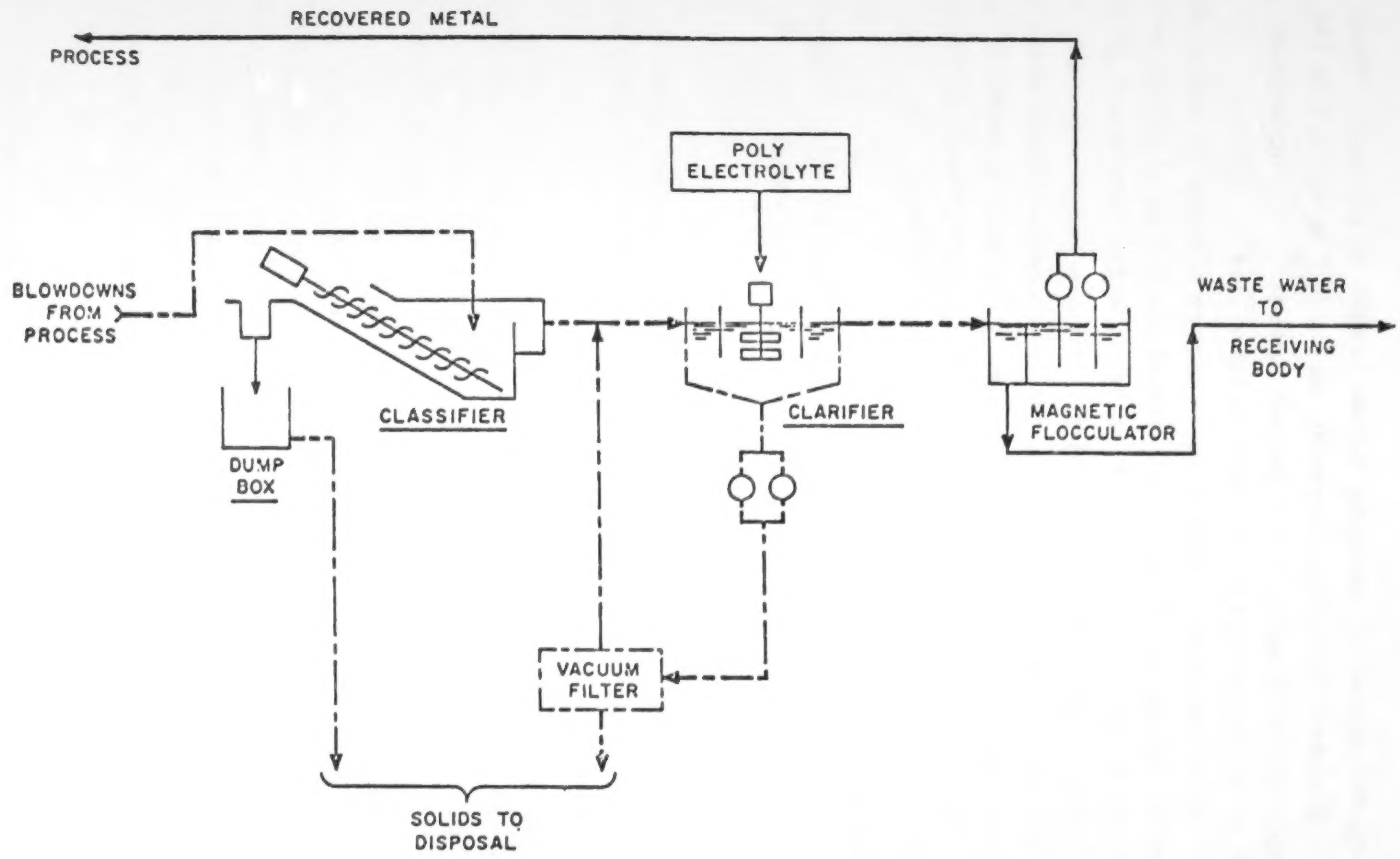

RECOVERED METAL
PROCESS
POLY ELECTROLYTE
BLOWDOWNS FROM PROCESS
WASTE WATER TO RECEIVING BODY
CLASSIFIER
CLARIFIER
MAGNETIC FLOCCULATOR
DUMP BOX
VACUUM FILTER
SOLIDS TO DISPOSAL

Figure 7-1. Proposed scrubber wastewater treatment system[8]

technology for removal of suspended solids is well established. "Best practicable control technology currently available," as defined by EPA, will reduce TSS to 50 mg/ℓ, a 99.8 percent removal.[7] The incremental increase in solids collection is shown in Table 7-14.

The use of the above treatment would require disposal of approximately 6.9 kg of solids per Mg of iron (13.8 lb/ton) and 8.0 kg of solids per Mg of steel (15.9 lb/ton). These solids would be in the form of a high-solids sludge containing up to 60 percent solids. Disposal of this quantity of sludge will not significantly increase the environmental impact above that of the baseline conditions. The sludge composition will be essentially the same as that of the particulate generated, which would require disposal regardless of the air pollution control technique employed.

7.3 SOLID WASTE DISPOSAL IMPACT

When scrubbers, precipitators, or fabric filters are used to control emissions from EAF's in iron or steel foundries, solid wastes, in the form of dust or sludge, will be generated.

7.3.1 Quantity of Solid Waste

The quantities of solid wastes that would be generated, based on the regulatory alternatives and emission limits presented in Tables 6-3 and 7-1, are shown in Table 7-15.

7.3.2 Composition of Solid Waste

Typical chemical analysis of electric arc furnace dust is given in Section 3.2. The major oxides are ferric oxide (Fe_2O_3) and silicon dioxide (SiO_2). There are also trace elements that may act as fluxes and have an effect on the melting behavior of the material.[10]

When the provisions of the Resource Conservation and Recovery Act (RCRA) are finalized, it is possible that EAF dust will be classified as a toxic waste. This classification results from the probability that some of the trace metals present in the dust would fail the leachability test. In the event that the dusts are clasified as toxic, the dusts generated by both the first (baseline) and second alternatives would be subject to the provisions of the RCRA.

7.3.3 Solid Waste Handling and Disposal

Dust collected from foundries is usually placed in landfills. Economic recycling of these iron-bearing dusts has not been demonstrated.

TABLE 7-15. SUMMARY OF SOLID WASTE GENERATION

Year after promulgation		1		2		3		4		5	
		Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel	Iron	Steel
Cumulative No. of new facilities of given size (mg/h)[a]	3.6	6	6	13	12	19	17	26	23	32	28
	9.1	3	3	6	7	9	11	12	14	15	18
	22.7	1	1	1	1	2	2	2	3	3	4
Nationwide baseline solid waste generated	Mg/yr	915	1,070	1,460	1,795	2,375	2,945	2,925	4,015	3,840	5,165
	(tons/yr)	(1,010)	(1,170)	(1,610)	(2,065)	(2,620)	(3,330)	(3,220)	(4,500)	(4,230)	(5,765)
Nationwide NSPS solid waste generated	Mg/yr	1,040	1,200	1,680	2,035	2,720	3,325	3,360	4,530	4,400	5,820
	(tons/yr)	(1,150)	(1,320)	(1,850)	(2,330)	(3,000)	(3,750)	(3,700)	(5,070)	(4,850)	(6,490)
Solid waste increase over baseline	Mg/yr	125	130	220	240	345	380	435	515	560	655
	(tons/yr)	(140)	(150)	(240)	(265)	(380)	(420)	(480)	(570)	(620)	(725)
	percent	14	12	15	13	15	13	15	13	15	13

[a] Facility size mix based on projected capacity increase (Table 8-4).

Should EAF dusts be classified as toxic under the provisions of RCRA, landfilling the solid waste along with municipal wastes would not be permitted. The dust would have to be placed in disposal sites secured for hazardous wastes.

Improper handling and disposal of particulates collected from the EAF can easily cause some reentrainment of dust to the atmosphere. The most effective method for handling dust is a pelletizing operation which practically eliminates reentrainment problems. Dust from the baghouses (or ESP's) can be emptied into sealed bags or containers which would also serve to contain dusts at the disposal site. Another option is to produce a slurry by injecting water into the dust handling system. Many foundries will probably continue to handle loose dust, usually transporting it by truck to the disposal site. Open-bodied trucks should have a cover placed over the load, and vehicle speed should be limited to avoid losses during transport.

7.3.3.1 Recycling Potential for EAF Dust. Dusts collected from foundry EAF's contain significant amounts of iron oxides. Recycle and recovery operations for steelmaking dusts are under investigation, but there are currently no commercial processes for recovering this material.

7.3.3.2 Landfill Disposal. Care in disposal of EAF dusts is necessary because, as shown in Table 7-16, relatively high levels of trace elements, including the toxic metals lead, cadmium, and arsenic, are often present.[11] These metals are present as metal oxides. Some of these oxides are soluble in pure water, and some are soluble in acidic solutions. The solubility of these compounds in acidic solutions may cause the dusts to fail the leachability test and thus be classified as toxic under the provisions of the RCRA.

Landfill site design for current practice must preclude horizontal or vertical migration of these metals to surface or groundwaters. The Safe Drinking Water Act of 1974 provides for protection of potential drinking water supplies and sets limits on the concentration of certain toxic metals. Where geohydrological conditions do not provide reasonable protection against leaching of these elements, technologies such as impervious liners are needed.

TABLE 7-16. TRACE METAL COMPONENTS OF BAGHOUSE HOPPER DUST[11]
(ppm)

Lead	(Pb)	10,000	Barium	(Ba)	200
Copper	(Cu)	8,000	Molybdenum	(Mo)	150
Zinc	(Zn)	5,000	Cadmium	(Cd)	100
Potassium	(K)	5,000	Arsenic	(As)	<100
Sodium	(Na)	3,000	Boron	(B)	50
Nickel	(Ni)	1,500	Vanadium	(V)	50
Tin	(Sn)	300	Cobalt	(Co)	50
Titanium	(Ti)	300	Antimony	(Sb)	<50
Lithium	(Li)	<300	Strontium	(Sr)	30
Chromium	(Cr)	200	Silver	(Ag)	10
Zirconium	(Zr)	200	Beryllium	(Be)	<1

When disposal is to a municipal landfill, dust must be segregated from municipal refuse. As organic matter decomposes, acidic conditions develop and portions of the trace metals in the dust could possibly dissolve. This would create the potential for leachate contamination of nearby waters.

Where wet scrubbers are used, scrubber wastewater should be contained in a settling pond and recirculated. Protection of groundwaters and surface waters is essential, and the landfill disposal requirements for scrubber sludge are the same as those for dust.

7.4 ENERGY IMPACT

Since fabric filters are projected as the control system of choice for both the baseline and NSPS alternatives, the incremental energy impact of the second alternative over the baseline will be negligible.

7.5 OTHER ENVIRONMENTAL IMPACTS

No increase in noise levels over those existing under baseline control is expected with the regulatory alternative.

7.6 OTHER ENVIRONMENTAL CONCERNS

If landfilling is used as the solid waste disposal technique, an irreversible land commitment might be required. The future usefulness of this land is dependent on the quantity and characteristics (chemical and physical) of the solid waste material. If toxic materials are present, the land may become unfit for agricultural and recreational use. However, if the landfill site is clay-lined, no irreversible impacts on the land should result from leaching of toxic materials.

When a venturi scrubber is employed as an emission control device, the blowdown wastewater must be disposed of. Both the type of treatment used and the wastewater disposal method may result in irretrievable and irreversible natural resource commitments. Water treatment in the form of a pond or lagoon will prevent alternate use of the land involved. The properties of the material pumped into the pond or lagoon will have the greatest effect in determining future alternative applications of the area. In most cases, ponds or lagoons are permanent installations.

A commitment of land for disposal purposes would be required under the baseline alternative. The incremental increase in the commitment would be the indeterminate extra amount required resulting from the increased dust or sludge load generated under the second alternative.

7.7 REFERENCES FOR CHAPTER 7

1. Memo and attachments from Schewe, G. J., EPA, to Cuffe, S., EPA. September 11, 1979. Air quality estimates of particulate emissions from electric arc furnaces in the iron and steel foundry industry.

2. Bowers, J. F., J. R. Bjorklund, and C. S. Cheney. Industrial Source Complex (ISC) Dispersion Model User's Guide. U.S. Environmental Protection Agency, Research Triangle Park, N.C. 2 Vols. EPA-450/4-79-030, 031. December 1979. Draft.

3. Larsen, R. I., A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. AP-89. November 1971. p. 9-10.

4. Air Quality Data--1977 Annual Statistics. U.S. Environmental Protection Agency, Research Triangle Park, N.C. EPA Report No. EPA-450/2-78-040. September 1978.

5. Air Quality Data--1978 First Quarter Statistics. U.S. Environmental Protection Agency, Research Triangle Park, N.C. EPA Report No. EPA-450/2-78-043. November 1978.

6. Development Document for Effluent Limitations Guidelines and New Source Performance Standards: Iron and Steel Foundry Industry. Draft Report. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Contract No. 68-01-1507. July 1974. p. 96-97.

7. Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Steel Making Segment of the Iron and Steel Manufacturing Point Source Category. U.S. Environmental Protection Agency. EPA Report No. EPA-440/1-74-024a. June 1974. p. 352-357.

8. Georgieff, N. T. Addendum to Standards Support and Environmental Impact for Electric Arc Furnaces in the Steel Foundry Industry. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Unpublished. December 1976.

9. U.S. Environmental Protection Agency. Code of Federal Regulations. Title 40, Chapter I, subchapter N, part 420. Washington, D.C. Office of the Federal Register. June 28, 1974.

10. Aleshin, E. Utilization of Waste By-Products. In: Transactions of the American Foundrymen's Society. Proceedings of the Seventy-Second Annual Meeting, April 29 to May 3, 1968. Vol. 76. Des Plaines, Ill., American Foundrymen's Society. 1968. p. 313-322.

11. Memo and attachments from Jungers, R. H., EPA, to Bibb, T., EPA. September 26, 1975. Gray iron foundry sample analysis.

8. ECONOMIC IMPACT

8.1 INDUSTRY CHARACTERIZATION

A brief description of the structure of the iron and steel foundry industry has been presented in Section 3.1 of this document. It is the intent in this section to expand on some of the information that appears in Section 3.1 and to establish the framework on which the economic impact analysis (Section 8.4) is based.

8.1.1 General Profile

8.1.1.1 Ferrous Castings Markets and Products. Markets for ferrous castings, which include iron castings (gray, ductile, and malleable) and steel castings, are widespread and include almost all segments of the economy. The major industry users of castings [by Standard Industrial Classification (SIC)] are summarized in Table 8-1. Large amounts of iron castings are used in almost all types of equipment, including motor vehicles, farm machinery, construction machinery, petroleum production and refining equipment, and iron-and-steel-industry equipment.

Steel castings are classified on the basis of their composition and heat treatment. For instance, general purpose castings made of carbon steel are the most widespread. They are used in earthmoving machinery, the automotive and transport industries, and agricultural and general machine manufacture. Heat-resistant castings, as the name implies, are high-alloy steel castings used in high temperature environments (e.g., steam and gas turbines, jet aircraft, oil refining machinery, and nuclear equipment). Corrosion-resistant steel alloy castings find application in the chemical industry. Wear-resistant steel castings, made of alloy steels, are versatile and are found on earthmoving machinery or shovel tracks, tramway spiders, parts of railway switches, side plates of crushers, pulverizers, and dipper brackets.

TABLE 8-1. END-USE DISTRIBUTION OF CASTINGS[1]

	SIC Code[a]	Industry[b]
A. Iron castings	3714	Motor vehicle parts and accessories
	3523	Farm machinery and equipment
	3519	Internal combustion engines, nec.[c]
	3494	Valves and pipe fittings
	3561,3	Pumps and compressors
	3585	Refrigeration and heating equipment
	3531	Construction machinery
	3566	Power transmission equipment
	3621	Motors and generators
	3541	Machine tools, metal cutting types
B. Steel castings	3743	Railroad equipment
	3531	Construction machinery
	3714	Motor vehicle parts and accessories
	3494	Valves and pipe fittings
	3495	Wire springs
	3559	Special industry machinery, nec.
	3561, 3	Pumps and compressors
	3728	Aircraft equipment, nec.
	3711	Motor vehicles and car bodies
	3533	Oil field machinery

[a] SIC = Standard Industrial Classification.
[b] Ranked by production (highest 10 listed).
[c] nec. = not elsewhere classified.

8.1.1.2 Plant Locations, Employment, and Structure. In 1978 there were 4,438 foundries of all types in the United States, including the following:[1]

Number of foundries	Metal cast
1,400	Gray iron
590	Ductile iron
107	Malleable iron
631	Steel

Some of these foundries may cast other metals in addition to iron or steel. In 1978 there were 1,074 electric arc furnaces in operation in 440 foundries of all types (e.g., iron, steel, nonferrous) in the United States. Other types of melting equipment may be used in addition to the electric arc furnace at a foundry, and a foundry may have more than one electric arc furnace.

Incomplete data indicate that there were at least 371 electric arc furnaces in use at gray and ductile iron foundries in 1973.[2] Table 8-2 presents data which indicates 396 electric arc furnaces were operational in steel foundries in 1977-78.[3] Table 8-2 also contains data on the total number of foundries, number of EAF's, and number of personnel at steel foundries with EAF's. The employment figures are estimates and include all personnel working at the company or foundry.

Industrywide data (includes non-EAF and nonferrous shops) for 1978 indicate an employment breakdown as follows:[1]

Number of employees	Number of foundries
1,000+	43
500 - 999	68
250 - 499	207
100 - 249	592
50 - 99	648
20 - 49	1,037
1 - 19	1,843

It is expected that ferrous EAF's will follow the same pattern, i.e., a large portion of the foundries having few employees. Specific data applicable only to ferrous EAF shops are not available.

TABLE 8-2. SUMMARY OF FOUNDRIES BY STATE[1,3]

	Total number of foundries all types[1] (1979)	Total number of foundries casting: Gray iron[1] (1979)	Ductile iron[1] (1979)	Malleable iron[1] (1979)	Steel[3] (1977-78)	Total number of EAF's all foundry types[1] (1979)	Total number of EAF's steel foundries[3] (1977-78)	Steel foundry EAF employment[3] (1977-78)
Alabama	94	53	25	1	8	37	13	1,790
Alaska	1	--	1	--	--	--	--	--
Arizona	21	4	2	2	3	12	9	680
Arkansas	44	11	4	--	1	5	2	200
California	431	80	35	3	15	54	26	3,690
Colorado	48	15	6	--	2	7	3	640
Connecticut	97	19	8	5	3	17	4	1,680
Delaware	6	1	--	--	2	3	3	708
District of Columbia	3	1	--	1	--	--	--	--
Florida	56	8	4	--	3	4	4	345
Georgia	47	18	9	8	3	7	6	360
Hawaii	2	1	--	--	--	2	--	--
Idaho	6	4	1	--	--	1	--	--
Illinois	319	75	34	6	15	55	31	7,000
Indiana	194	72	23	3	10	30	16	5,085
Iowa	74	31	11	1	2	20	4	940
Kansas	55	24	11	--	2	7	4	1,375
Kentucky	28	13	1	1	--	1	--	--
Louisiana	24	9	1	--	4	30	10	1,285
Maine	13	6	1	--	--	--	--	--
Maryland	24	8	5	--	--	4	--	--
Massachusetts	137	41	16	2	2	15	3	315

TABLE 8-2. SUMMARY OF FOUNDRIES BY STATE[1,3]
(continued)

	Total number of foundries all types[1] (1979)	Total number of foundries casting: Gray iron[1] (1979)	Ductile iron[1] (1979)	Malleable iron[1] (1979)	Steel[3] (1977-78)	Total number of EAF's all foundry types[1] (1979)	Total number of EAF's steel foundries[3] (1977-78)	Steel foundry EAF employment[3] (1977-78)
Michigan	351	111	52	15	11	134	24	3,100
Minnesota	91	34	8	1	2	10	3	800
Mississippi	14	7	--	1	1	2	1	160
Missouri	116	29	8	2	11	26	15	2,870
Montana	3	2	1	1	--	--	--	--
Nebraska	20	6	--	--	1	4	1	170
Nevada	4	2	--	--	1	1	1	25
New Hampshire	31	7	1	1	1	14	2	155
New Jersey	130	22	14	1	3	24	4	695
New Mexico	14	1	--	--	--	--	--	--
New York	265	59	23	7	9	52	16	3,915
North Carolina	52	23	7	--	--	2	--	--
North Dahota	1	--	--	--	--	--	--	--
Ohio	456	154	70	14	22	92	35	7,265
Oklahoma	46	22	18	--	2	5	3	670
Oregon	54	12	7	--	5	19	12	1,395
Pennsylvania	375	144	66	20	27	97	54	12,850
Rhode Island	49	5	1	1	--	--	--	--
South Carolina	28	13	5	--	--	6	--	--
South Dakota	3	2	1	--	--	--	--	--
Tennessee	80	35	11	1	2	3	3	465
Texas	183	62	34	5	13	56	22	2,995

TABLE 8-2. SUMMARY OF FOUNDRIES BY STATE[1,3] (concluded)

	Total number of foundries all types[1] (1979)	Total number of foundries casting				Total number of EAF's all foundry types[1] (1979)	Total number of EAF's steel foundries[3] (1977-78)	Steel foundry EAF employment[3] (1977-78)
		Gray iron[1] (1979)	Ductile iron[1] (1979)	Malleable iron[1] (1979)	Steel[3] (1977-78)			
Utah	16	11	5	1	1	4	2	230
Vermont	4	4	1	--	--	1	--	--
Virginia	48	28	7	--	1	8	3	400
Washington	56	18	9	3	11	24	21	1,740
West Virginia	26	10	5	1	1	4	1	120
Wisconsin	197	81	38	7	15	70	35	6,210
Wyoming	2	1	1	--	--	2	--	--

Larger iron furnaces, 9 to 14 Mg/h (10 to 15 tons/h), are usually located in integrated machinery producing plants. Smaller furnaces, down to a fraction of a ton per hour, are located in plants that produce either a limited variety of products or small quantities of speciality iron castings. Small furnaces are usually operated periodically; large furnaces usually are operated in two shifts. Industrywide, the ratio between jobbing and captive foundries is approximately 3.5:1.[1] This value is assumed to hold for the iron EAF segment also.

Almost all facilities that produce steel castings are jobber (i.e., produce castings for sale to or use by other companies) foundries. Very few arc furnaces that melt steel are part of integrated plants. Smaller furnaces are located in plants that produce a limited variety of products or small quantities of special steel castings. Small steel foundries operate their arc furnaces periodically; larger foundries usually are operated in two shifts.

8.1.1.3 Market Competition. Since the majority of ferrous facilities are jobber foundries, competition for product markets is prevalent. Large (over 20 Mg/h) foundries compete with other large foundries for the same markets. For example, large pipe foundries will compete with other large pipe foundries for these markets; large foundries that produce parts for motor vehicles will compete with other large foundries producing similar castings even though part of the large foundries are captive. These very large foundries are generally fully automated and produce large numbers of similar parts. This repetitive production of large numbers of castings with automated equipment permits the large foundries to produce castings at a minimum cost.

Medium-size foundries (7 to 20 Mg/h) generally produce a wider range of casting designs and make fewer of each design than do the large foundries. Most medium-size foundries have some automated equipment for making large numbers of castings but seldom will make the same casting design every day. Medium-size foundries have a higher unit cost than do large foundries.

Smaller foundries must find markets that are unattractive to medium-size or large foundries. These markets for very small jobbing foundries include replacement parts where only a few castings are needed, castings for customers that only need a few parts per month, and some very low quality castings (e.g., counterweights or manhole covers) where very little quality control is required. The very small foundry cannot compete with medium-size or large foundries for the casting markets of interest to the larger foundries.

A few small foundries compete with other small foundries for speciality markets such as piano-plate castings or alloy-extrusion augers. These small, specialty foundries generally are a part of a captive operation and are not jobbing foundries.

8.1.1.4 Product/Substitute Competition. The various types of iron castings (gray, ductile, and malleable) frequently compete with each other, with steel and nonferrous castings, steel weldments, powdered-metal parts, metal forgings and stampings, and plastics for the same markets. The material of lowest initial cost may or may not be the one selected for use. Not only must a product meet the desired physical and mechanical properties, but differences in machinability, weldability, performance in service, service life, and the cost of repairs and downtime can have marked effects on total cost during the life of the product.

For medium- and large-size parts, gray and ductile iron generally compete with each other and with steel castings. Frequently, use of either gray iron or ductile iron will result in a part at the lowest cost. Sometimes, when only a few parts of a given design are required, weldments are more economical to use than castings. Forgings may be competitive for medium-size parts but not for large parts.

Some castings, such as gray iron ingot molds and motor blocks, have little or no competition whatsoever because no other material will perform satisfactorily in that application. Ingot molds are being replaced, however, by a change in technology to the production of continuously cast slabs and billets. Some competition is being provided in the motor block area by aluminum castings made in permanent molds.

The rapid growth of ductile iron results from its replacement of steel castings in many applications and, to a lesser extent, replacement of gray and malleable iron castings. Ductile iron soil pipe has become very popular with municipalities because, unlike gray iron, ductile iron can withstand some shifting of the soil without breaking. Ductile iron also has good resistance to soil corrosion and is superior in that respect to carbon steel.

8.1.2 Trends.

Table 8-3 presents trend data (historic and projected) for casting shipments, product value, employment, and balance of trade.

8.1.2.1 Shipments. In 1978, the ferrous castings industry shipped 16.85 million Mg (18.55 million tons). This represented about a 5 percent increase over the 1977 level. Ferrous casting shipments in 1979 were projected to rise 5 percent over the 1978 level, representing the fourth consecutive annual increase.[4] Rising capital goods purchases by industry, especially railroad equipment and industrial machinery of all kinds, together with high-level automobile and truck output, were expected to support increased casting production.

Gray iron castings (including ductile iron) remain the major product of ferrous foundries, comprising 85 percent of the 1977 output and about 81 percent of 1978 shipments.[4] Gray iron shipments in 1978 were about 11.7 million Mg (12.9 million tons), in addition to approximately 2.7 million Mg (3 million tons) of ductile iron. Gray iron shipments in 1977 totaled 13.63 million Mg (15.03 million tons), in addition to 2.46 million Mg (2.71 million tons) of ductile iron. In 1979, gray iron shipments were forecast to reach 12.1 million Mg (13.4 million tons) while ductile iron castings were also expected to gain, reaching an estimated 3.0 million Mg (3.3 million tons). Malleable iron castings shipments have been more stable as ductile iron preempts some markets. Malleable iron shipments were expected to total 771,000 Mg (850,000 tons) in 1978 and 798,000 Mg (880,000 tons) in 1979. In 1977, production of malleable iron castings totaled 752,700 Mg (829,700 tons).

Steel castings shipments, buoyed by railroad car construction, were especially active in 1979. Orders for railroad car component castings were largely on extended delivery terms with contracts quite frequently covering the entire annual requirements of car builders.[4] Almost 50 percent of the 1979 steel castings production was forecast for railcar uses compared with 35 to 40 percent in the years prior to 1979. The probability that railcar output would remain strong in 1979, coupled with improved demands for machinery components, indicated continuing growth for steel

TABLE 8-3. FERROUS CASTINGS: TRENDS AND PROJECTIONS 1972-1983[4,5]

	1972	1973	1974	1975	1976	1977	1978	1979[a]	1980[a]	1981[a]	1982[a]	1983[a]
Product												
Quantity shipped, total (10^3 Mg)	16,225	18,118	16,933	13,712	15,265	15,950	16,828	17,682	18,300	18,941	19,604	20,290
Gray iron (10^3 Mg)	12,240	13,427	12,210	9,636	10,827	11,182	11,703	12,166	---	---	---	---
Ductile iron (10^3 Mg)	1,665	2,038	1,998	1,655	2,035	2,456	2,721	2,994	---	---	---	---
Malleable iron (10^3 Mg)	872	935	829	663	767	753	771	798	---	---	---	---
Steel (10^3 Mg)	1,448	1,718	1,896	1,758	1,636	1,559	1,633	1,724	---	---	---	---
Quantity shipped, total (10^3 tons)	17,885	19,972	18,666	15,115	16,827	17,582	18,550	19,491	20,173	20,879	21,610	22,366
Gray iron (10 tons)	13,493	14,801	13,459	10,622	11,935	12,326	12,900	13,411	---	---	---	---
Ductile iron (10^3 tons)	1,835	2,246	2,203	1,824	2,243	2,707	3,000	3,300	---	---	---	---
Malleable iron (10^3 tons)	961	1,031	914	731	846	830	850	880				
Steel (10^3 tons)	1,596	1,894	2,090	1,938	1,803	1,719	1,800	1,900	---	---	---	---
Value of shipments[b] ($ million)	5,807	7,129	8,779	9,127	10,072	11,751	14,578	16,946	18,302	19,766	21,347	23,055
Average value $/Mg ($/ton)	357.90 (324.70)	393.48 (356.90)	518.46 (470.30)	665.62 (603.80)	659.81 (598.60)	736.74 (668.40)	866.24 (785.90)	938.38 (869.40)	1,000.11 (907.30)	1,043.56 (946.70)	1,088.91 (987.80)	1,136.27 (1,030.80)
Industry												
Total employment (.0^3)	216	236	239	221	216	220	231	242	250	259	268	278
Production workers (10^3)	181	200	203	184	179	180	189	198	205	212	220	227
Value of shipments[b] ($ million)	5,647	6,858	8,535	8,871	9,787	11,418	14,165	16,438	---	---	---	---
Trade												
Value of exports[b] ($ million)	114	157	223	281	283	291	302	315	---	---	---	---
Value of imports ($ million)	37	48	73	76	79	110	132	162	---	---	---	---

[a] Projected data.
[b] 1979 dollars.

castings beyond the anticipated 1978 shipment level of 1.6 million Mg (1.8 million tons). Shipments of steel castings during 1979 were expected to reach 1.7 million Mg (1.9 million tons).[4] In 1977, these shipments were reported at 1.56 million Mg (1.72 million tons).

Production of ferrous castings is largely influenced by the general economic climate, and, consequently, shipments from iron foundries decreased from 16.4 million Mg (18.1 million tons) in 1973 to 13.9 million Mg (15.3 million tons) in 1976. Shipments of steel castings dropped slightly from 1.71 million Mg (1.89 million tons) in 1973 to 1.63 million Mg (1.80 million tons) for 1976. Production of ferrous castings in 1976, however, was substantially improved over 1975 due to an easing of material shortages, increased demand by the automobile industry, and general improvement of the economy. Future demand for ferrous castings is considered to be strong. Many unknowns remain in proposed environmental and health standards and the problem of generating capital to meet these responsibilities is an important factor in the health of this industry. Substantial growth in modern, technologically advanced foundries is occurring which has reduced the labor component of foundry cost to below 50 percent of the total production costs.[4] New moldmaking processes will likely keep castings competitive with other modes of fabrication for machinery parts.

According to 1979 projections made by the Department of Commerce, the market for ferrous castings is expected to grow at a faster rate in the next 5 years than is the market for steel mill products, the industry's largest component.[4] A growth rate of 3.5 percent per year may be realized, reaching 20.3 million Mg (22.4 million tons) shipped in 1983. The value of product shipments was predicted to rise at a faster rate, 8 percent per year, and total $23 billion in 1983. For the purposes of this profile, employment in the ferrous castings industry was also projected to increase at a rate of 3.5 percent per year.

8.1.2.2 Prices/Product Values. The higher volume of shipments anticipated in 1979 was expected to be shared, across the casting industry, including the large foundries captive to other industries and small independent jobbing foundries, and by various types of cast iron and cast steel products. The value of shipment increases is expected to substantially exceed the tonnage increases, however, reflecting continuing price increases for cast products. The value of ferrous castings shipments is projected to rise 16 percent in 1979, compared to an estimated 24 percent increase in 1978.[4]

The value of industry shipments for ferrous castings in 1978 was estimated at $14.16 billion, compared with $11.42 billion in 1977. The value of industry shipments includes the value of all products and services sold by the ferrous castings industry (SIC 332). The value of product shipments (i.e., value of shipments of ferrous castings produced by all industries) reached $11.75 billion in 1977, was expected to reach $14.58 billion in 1978, and then rise to $16.95 billion by the end of 1979 (a 16 percent increase over 1978).

The value of gray and ductile iron shipments in 1979 was forecast to increase 15 percent to $12.4 billion, reflecting price increases in addition to growth in volume.[4] A 7 percent tonnage gain was estimated for 1978 with almost as large a gain forecast for 1979. In dollar terms, steel castings shipments were expected to rise more sharply, by 19 percent in 1978 and 22 percent in 1979.[4] The average value of all product shipments has increased from $356.90/Mg ($324.69/ton) in 1972, to $958.38/Mg ($869.43/ton) in 1979. The compound annual rate of change from 1973 to 1978 in the value of product shipments has been 15.4 percent based on current dollars.[4]

8.1.2.3 Import/Export. In 1978, the value of the combined exports of gray, ductile, and malleable iron castings and of steel castings was 2.1 percent of the value of all domestic shipments of ferrous castings and the value for combined imports was 0.9 percent of the total value. These percentages have changed very little over the past 10 years and are not expected to significantly alter in the future. Each year, export shipments are usually about 2 percent of all shipments while import totals are generally less than 1 percent. The United States continues to enjoy a positive balance of trade in ferrous castings of more than two to one. Current figures for castings exports are less precise than formerly due to revised data gathering procedures and the fact that measurement of trade must be approximated. For example, trade volumes in component parts for machinery, especially automobiles, and for construction end uses is considerable, particularly on the import side. Much of this trade is reported as various machinery and not as castings; thus, the impact on castings markets is not amenable to accurate measurement.

The compound annual rate of change during the period of 1973 through 1978 was 14 percent on the value of exports and 22.5 percent on the value of imports.[4] The trade balance favorable to the United States has widened from $109 million in 1973 to $170 million in 1978.

Major castings exporters to the United States are Canada, the Federal Republic of Germany, Japan, France, the United Kingdom, and India. In order of dollar value, Canada exceeds the next two largest countries and represents a third of the total value of imports of castings. Canada is also the largest export market for U.S. castings, followed by Mexico and Western Europe. In 1978, the value of foreign trade in castings, capable of being measured, was estimated at less than 4 percent of the value of the domestic market for castings.[4]

The exportation and importation of ferrous castings at present are small in volume and, therefore, have minor effects on the industry. The balance of trade in this industry is not expected to change drastically even if economic conditions or government controls increase the cost of producing castings in the United States. Castings are different from each other in form and complexity. Speciality casting buyers often visit the vendor to discuss the problems and arrange for sample castings to be delivered. After the samples are delivered, the design may be changed one or more times to improve the product in which the castings are used. The frequent monitoring of the casting design, casting scrap, and the production of castings does not lend itself to long-distance negotiations.

Some castings, such as pressure pipe, soil pipe, and malleable iron pipe fittings, are fairly standard in design. However, differences in size because of the metric versus English units of measure make international trade difficult even for those items.

Many castings, such as motor blocks and heads, brake drums, and ingot molds, are made in large numbers and could be a part of international trade. However, castings of these types have not been standardized, and each company demands individual designs. The freight on heavy ingot molds is also a problem.

Certain standard castings are imported in relatively large quantities, including steel valves and valve bodies, pump cases and related fittings, and large hydraulic turbine castings. These castings come primarily from the Far East where the production costs have been reduced through mechanization and high efficiency.

Under present conditions, long lead times of up to a year or more are required between the placement of an order for castings and the receipt of the first production castings. These slow deliveries are even slower when castings must be shipped long distances, and this is another factor that tends to discourage foreign trade. (Even when foundry production is low, lead times of about six months are required.) These various factors encourage a close geographical location of casting producers and customers and tend to limit international trade.

8.1.2.4 Facility Projections. The projected demand will be met by a combination of existing unused capacity and by construction of new facilities. Only 73 percent of available capacity was used in 1976, and current plans for new equipment will increase foundry capacity by 18 percent by 1981.[6] Although demand for castings is subject to cyclic swings, iron is expected to account for a majority (85 percent) of ferrous metal castings in the future.

According to a survey of foundrymen made during 1977, 71 percent of the industry was planning some type of capital improvement in 1978.[7] Those plans included new plants, plant additions, and new equipment. Overall, 4 percent of the industry planned new facilities. Plant additions ranged from none (malleable foundries) to 29 percent for steel foundries. In new equipment considerations during 1978, 65 percent (steel) to 81 percent (ductile iron) of producers reported plans for new equipment purchases. Melting equipment led the list of equipment plans.

New installations of electric arc furnaces at foundries have increased steadily over recent years. In fact, the growth of arc melting in the foundry industry has been dramatic in the 1970's--doubling in 7 years--and it is anticipated that this momentum will continue into 1983. In 1970, capacity of iron and steel electric furnaces was 3.2 million Mg (3.5 million tons). By 1983, it is estimated that the capacity will be 8.3 million Mg (9.2 million tons).[8] The estimated year-end EAF capacity for the period 1976 to 1983 is presented in Table 8-4. No projections are available beyond 1983. The capacity figures will be larger than the shipment figures as a result of the production of foundry returns and defective castings.

For new installations, arc furnaces are somewhat more common than the traditional cupola because of improved metallurgical control, reliable energy sources, and relative ease of air pollution control. Escalating electricity costs, coupled with improvements in the design and operation of the cupola, suggest that a significant percentage of iron will continue to be melted in this type of furnace.

By nearly a two-to-one margin, capacity expansion of EAF facilities in the last 5 years resulted from adding furnace units to existing shops rather than by building new shops. Information on capacity expansion, provided by one source, is presented in Table 8-5. The expansion trend of adding furnaces to existing shops is expected to continue.

8.2 COST ANALYSIS OF CONTROL OPTIONS

In this section, the estimated capital and annualized costs are presented for the control systems, model plants, and regulatory alternatives outlined in Chapter 6. The costs for retrofitting the control systems to modified/reconstructed facilities outlined in Chapter 5 have not been determined since the likelihood of modification or reconstruction is considered remote.

8.2.1 Introduction

The model plants and control options have been described in Chapter 6. The model plant parameters are summarized in Tables 8-6 and 8-7. These tables provide the information on unit size, production, energy usage, and flow rate necessary for the subsequent cost analyses.

The regulatory alternatives and associated emission levels are presented in Table 8-8. The first alternative (baseline) provides for no additional regulatory action by EPA, but relies on the typical State regulation (presented in Section 3.3) to control emissions from foundry EAF operations. The second alternative would utilize the same control equipment as would be

TABLE 8-4. ESTIMATED YEAR-END FOUNDRY ELECTRIC ARC FURNACE CAPACITY[8]
[10^6 Mg (10^6 tons)]

Year	Iron	Steel	Total
1976	3.0 (3.3)	3.0 (3.3)	6.0 (6.6)
1977	3.4 (3.7)	3.2 (3.5)	6.6 (7.2)
1978	3.5 (3.9)	3.4 (3.7)	6.9 (7.6)
1979	3.5 (3.9)	3.4 (3.8)	6.9 (7.7)
1980	3.6 (4.0)	3.6 (4.0)	7.2 (8.0)
1981	3.8 (4.2)	3.9 (4.3)	7.7 (8.5)
1982	4.1 (4.5)	4.1 (4.5)	8.2 (9.0)
1983	4.2 (4.6)	4.2 (4.6)	8.4 (9.2)

TABLE 8-5. EXPANSIONS IN ELECTRIC ARC FURNACE FACILITIES[8]

	Furnace				
	Number	Size[a]		Year of startup	Type of expansion
		Mg	ton		
1	2	9.1	10	1975	New iron foundry
2	1	5.4	6	1975	New steel foundry
3	3	18.1	20	1976	Expansion - iron
4	1	9.1	10	1976	Expansion - steel
5	3	18.1	20	1977	New steel foundry
6	1	45.4	50	1977	Expansion - steel
7	1	13.6	15	1977	Expansion - steel
8	1	13.6	15	1977	Expansion - steel
9	1	45.4	50	1977	Expansion - steel
10	1	40.8	45	1978	New iron foundry
11	1	4.5	5	1979	Expansion - steel
12	2	31.8	35	1980	Expansion - steel
13	1	27.2	30	1980	Expansion - steel
14	3	22.7	25	1981	New steel foundry

[a] Foundry capacity is recorded in tons of castings shipped and not in terms of molten iron or steel produced. Therefore, it is not possible to give a typical size of melting furnaces in terms of production rate.

TABLE 8-6. MODEL PLANT PARAMETERS - COMMON

Model plant	Furnace size		EAF production		Operating time[a]	Land area		EAF process energy usage[b]		Furnace size designation
	Mg/h	ton/h	Mg/yr	tons/yr	h/yr	$10^5 m^2$	acres	10^{12} J/yr	10^6 kWh/yr	
1	3.6	4	5,760	6,400	1600	0.40	10	12.0	3.4	Small
2	9.1	10	17,500	19,200	1920	2.02	50	36.5	10.1	Medium
3	22.7	25	63,600	70,000	2800	4.05	100	133	36.8	Large

[a] Based on one 8-h shift/day: 200 d/yr small furnace, 240 d/yr medium furnace, and 350 d/yr large furnace.

[b] Based on 2,085 MJ/Mg (525 kWh/ton) of metal produced.

TABLE 8-7. MODEL PLANT PARAMETERS - SPECIFIC

Control system	Gas temp at fan °C (°F)	Exhaust air flow m^3/s (ft^3/min)			Emission control energy usage 10^{12} J/yr (10^6 kWh/yr)		
		Small	Medium	Large	Small	Medium	Large
Side draft hood and baghouse	121 (250)	13.0 (27,500)	28.3 (60,000)	70.8 (150,000)	0.58 (0.16)	1.51 (0.42)	5.47 (1.52)
Direct furnace evacuation and baghouse	121 (250)	-- --	8.5 (18,000)	21.2 (45,000)	-- --	0.47 (0.13)	1.66 (0.46)

TABLE 8-8. REGULATORY ALTERNATIVES AND CONTROL SYSTEM OPTIONS

Regulatory alternative/ control option	Total emissions kg/h (lb/h)[a]					
	Iron			Steel		
	Small	Medium	Large	Small	Medium	Large
Alternative 1 (baseline)						
Side draft hood and baghouse	7.2 (15.9)	15.1 (33.2)	31.9 (70.4)	7.6 (16.8)	-- --	-- --
Direct furnace evacuation and baghouse	-- --	-- --	-- --	-- --	16.0 (35.2)	34.2 (75.4)
Alternative 2 (melting and refining only)						
Side draft hood and baghouse	2.9 (6.4)	7.2 (15.9)	18.1 (39.8)	3.3 (7.3)	-- --	-- --
Direct furnace evacuation and baghouse	-- --	-- --	-- --	-- --	7.5 (16.6)	18.8 (41.5)
Emission reduction over baseline	4.3 (9.5)	7.9 (17.3)	13.8 (30.6)	4.3 (9.5)	8.5 (18.6)	15.4 (33.9)
Percent	60	52	43	57	53	45

[a] Includes fugitive emissions from Table 3-12.

used to meet the baseline alternative but would have a more stringent emission limit.

The capture and control equipment, assumed for both regulatory alternatives, is a side draft hood and fabric filter for all size iron EAF's and small steel EAF's and direct furnace evacuation and fabric filter for medium and large steel EAF's (Section 4.3). The only economic differences assumed between the two regulatory alternatives are more frequent bag replacement for the second alternative over that performed for the baseline alternative and continuous monitoring of the control device exhaust gas opacity for the second alternative. All costs are given in first quarter 1979 dollars.

8.2.2 New Facilities

This section presents the cost estimates associated with new EAF foundry construction. Unless noted otherwise, the cost data have been updated from previous documents using either the Chemical Engineering (CE) plant cost index or the Marshall and Swift (M&S) equipment cost index.[9]

8.2.2.1 Capital Costs. Table 8-9 presents the capital cost estimates for the two regulatory alternatives. Since the control equipment is the same for both alternatives, the only incremental cost increase is incurred through the use of continuous opacity monitors for the second alternative. These costs were updated from Reference 10 using the M&S equipment cost index and corrected for size using the ratios of the air flow rates. Information for the capital costs was originally developed through EPA contractor studies and files and also from contacts with foundry operators, equipment vendors, and design engineering firms.[10]

These estimates include the cost of designing, purchasing, and installing the capture systems, control devices, and continuous monitors. They include costs for both major and auxiliary equipment, rearrangement or removal of existing equipment, site preparation, equipment installation, and design engineering. Specific items that are included are control hardware, fans, ductwork, stacks (where required), dust handling equipment, storage, taxes, freight, engineering, supervision, labor, vendor overhead, performance acceptance tests, and startup costs. The capital costs

TABLE 8-9. CAPITAL COST ESTIMATES FOR REGULATORY ALTERNATIVES (10³ dollars)[a]

Furnace size		Capital cost			
		Baseline		NSPS	
Mg/h	tons/h	Iron	Steel	Iron	Steel
3.6	4	233.2[b]	233.2[b]	251.2[b]	251.2[b]
9.1	10	531.5[b]	179.6[c]	550.5[b]	198.6[c]
22.7	25	1,179.5[b]	356.1[c]	1,199.5[b]	376.1[c]

[a] 1979 dollars.
[b] Side draft hood and baghouse.
[c] Direct furnace evacuation and baghouse.

range from 14 to 23 percent of the total facility costs presented in Section 8.2.2.4.

8.2.2.2 Annualized Costs. Table 8-10 presents the annualized cost estimates for the two regulatory alternatives. The annualized costs consist of the sum of the fixed costs (capital charges, taxes, insurance) and the annual operating expenses. The only incremental cost increase realized through the use of the second alternative over the baseline alternative results from the increased bag replacement required to meet the more stringent emission limit of the second alternative and the continuous monitoring.

The capital charges have been calculated on the basis of 100 percent debt financing and recovery of capital by uniform periodic payments [capital recovery factor (CRF)]. The useful life for all equipment has been assumed as 15 years. A 10 percent interest rate was assumed. The property taxes, insurance, general, and administrative costs were based on 4 percent of the total capital requirement or approximately 6 percent of the installed equipment cost. The labor cost was based on 0.4 person-year/year and $15.00 per labor hour. Maintenance costs were based on 1.0 percent of the total capital requirement or 1.5 percent of the installed equipment cost. Energy costs were assumed to be 4¢/kWh. Fabric filter bag replacement costs were based on an assumed replacement every year in the second alternative and every three years in the baseline case.

No recovery credit has been assumed for the collected dust. Some increased costs may be realized for dust disposal due to the increased amounts collected under the second alternative. No estimate could be made, however, of the amount of this potential cost increase. Also, no estimate was made of the cost of increased bag disposal.

8.2.2.3 Cost Effectiveness. The marginal cost effectiveness of the second alternative is shown in Table 8-11. The marginal cost effectiveness varies between the iron and steel foundries and ranges from $489/Mg ($446/ton) for the 22.7-Mg (25-ton) steel furnace to $1,962/Mg ($1,776/ton) for the 3.6-Mg (4-ton) iron furnace.

8.2.2.4 Base Cost of Facility. The facility costs presented in Table 8-12 have been updated from Reference 11 using the CE plant cost index. These costs represent the estimated costs for installing electric

TABLE 8-10. ANNUALIZED COST ESTIMATES FOR REGULATORY ALTERNATIVES (10³ dollars/yr)

Control option	Side draft hood with baghouse						Direct furnace evacuation with baghouse			
Foundry type	Iron and small steel						Medium and large steel			
	Baseline			NSPS			Baseline		NSPS	
Furnace size (Mg/h)	3.6 small	9.1 medium	22.7 large	3.6 small	9.1 medium	22.7 large	9.1 medium	22.7 large	9.1 medium	22.7 large
Capital charge	30.7	69.9	155.1	33.0	72.4	157.7	23.6	46.8	26.1	49.5
Property tax, insurance, general and administrative	9.3	21.3	47.2	10.0	22.0	48.0	7.2	14.2	7.9	15.0
Total fixed costs	40.0	91.2	202.3	43.0	94.4	205.7	30.8	61.0	34.0	64.5
Labor cost	4.8	5.8	8.4	9.6	11.5	16.8	5.8	8.4	11.5	16.8
Bag replacement cost	2.8	6.0	12.0	8.3	18.0	36.0	1.8	4.5	5.4	13.5
Maintenance cost	2.3	5.3	11.8	2.5	5.5	12.0	1.8	3.6	2.0	3.8
Utilities cost	6.4	16.8	60.8	6.4	16.8	60.8	5.2	18.4	5.2	18.4
Total operating costs	16.3	33.9	93.0	26.8	51.8	125.6	14.6	34.9	24.1	52.5
Annualized costs	56.3	125.1	295.3	69.8	146.2	331.3	45.4	95.9	58.1	117.0
Increase over baseline				13.5	21.1	36.0			12.7	21.1

[a] 1979 dollars.

TABLE 8-11. MARGINAL COST EFFECTIVENESS OF THE SECOND ALTERNATIVE[a]

Furnace size		Cost effectiveness[b]			
		Iron		Steel	
Mg/h	tons/h	$/Mg	($/ton)	$/Mg	($/ton)
3.6	4	1,962	(1,776)	1,962	(1,776)
9.1	10	1,384	(1,270)	778	(711)
22.7	25	932	(840)	489	(446)

[a] 1979 dollars.
[b] Annualized dollars per incremental unit weight particulate removed.
[c] Based on operating hours from Table 8-6 and emissions from Table 8-8.

TABLE 8-12. BASE COST OF INSTALLING ELECTRIC ARC FURNACES IN FOUNDRIES[a]

Furnace size		Base cost (10^6 dollars)
Mg/h	tons/h	
3.6	4	1.772
9.1	10	2.658
22.7	25	5.170

[a] 1979 dollars.

arc furnaces as the primary melting unit in a foundry and are assumed to be valid for either iron or steel production. The costs include the arc furnace(s), electrical transformers, charging equipment, holding furnace(s), spare parts, and air pollution control equipment (for baseline level of control). Equipment and installation costs are included in the total.

8.3 OTHER COST CONSIDERATIONS

This section summarizes the impacts currently being imposed on the iron and steel foundry industry in general and the electric arc furnace affected facility in particular as a result of other environmental regulatory actions (water, solid waste, and occupational health). The impact of the regulatory alternatives on the cost to the industry of compliance testing and the resource requirements of local, State, and regional regulatory and enforcement agencies is also addressed.

8.3.1 Water Pollution Regulations

Water effluents from foundry operations come from four basic operations.[12] These are:

1. melting (cooling and gas cleaning);
2. molding (gas cleaning);
3. casting cleaning (gas cleaning and cast rinsing); and
4. heat treating (quenching).

Of these sources, only the melting source is directly attributable to the EAF. Any cooling water systems used for EAF door, electrode glands, roof ring, or transformer systems are usually either once-through or closed recirculating systems. The water discharge is of a quality equal to the input stream but of a somewhat higher temperature. Water sprays may be used to cool the gas stream prior to the control device, but when properly designed and operated, there is no aqueous discharge.[12] If a wet scrubber is used as the control device, a water pollution impact could be generated, but scrubbers are not recommended for use on EAF's. Thus, the use of an EAF will not increase the water treatment load of a foundry, nor will there be any incremental increase over baseline as a result of the second alternative.

In order for a typical foundry (272 Mg/d, 300 tons/d) to meet the proposed 1983 water quality standards for all of its effluent streams, an energy consumption increase of 43 MJ/Mg (12 kWh/ton) of metal produced has been estimated.[12] Compared to the EAF furnace process energy consumption presented in Chapter 6 (2,085 MJ/Mg, 525 kWh/ton), this value is inconsequential and would have no effect on the ability of an EAF foundry to meet the second alternative.

8.3.2 Solid Waste Regulations

EAF wastes do not currently fall under the provisions of the Resource Conservation and Recovery Act (RCRA). Thus, solid waste restrictions do not impact on the ability of an EAF foundry to meet the second alternative. As noted in Section 7.3, however, when the provisions of RCRA are finalized, EAF dusts may be classified as toxic. The current practice of landfilling EAF dusts is expected to continue until such time as a toxic waste determination under RCRA is made. The only cost increase due to the second alternative will result from the increased quantities of dust which will be generated.

At this time, the costs associated with compliance with the provisions of RCRA can only be estimated. The costs for toxic waste handling and disposal range from \$15 to \$70 per Mg (\$13.60 to \$63.50 per ton), depending on the toxicity of the waste.[13] Based on these costs, the hauling and disposal costs for the additional dust created by the second alternative would range from \$235 to \$1,095 per plant per year for the 9.1-Mg/h (10-ton/h) model plant, a maximum annualized cost increase of 0.02 percent. These costs have not been included in the impact analyses of Section 8.4 because the RCRA provisions do not yet apply to this industry.

8.3.3 Environmental Health Regulations

No data were obtained regarding the cost to a foundry of compliance with the Occupational Safety and Health Administration Act (OSHA). Since the same control equipment is forecast for use under the second alternative as under the baseline condition, no incremental cost impact is expected as a result of the second alternative.

8.3.4 Compliance Test Costs and Regulatory Agency Resource Requirements

The cost borne by the EAF foundry for the compliance testing of a new facility would be approximately \$10,000 for a set of three particulate and visible emission tests per control device.

The facility is responsible for making application to the State for a permit to construct and subsequently operate a new installation. The review of these applications, and any later enforcement action, would be handled by local, State, or regional regulatory agencies. Since it is assumed that only 10 EAF units per year will become affected facilities through 1983, that these plants will be distributed through the United States instead of clustered in one State, and that they will be added in States already having foundry facilities, the promulgation of standards for this affected facility should not impose major resource requirements on the regulatory agencies.

8.4 ECONOMIC IMPACT OF REGULATORY ALTERNATIVES

8.4.1 Introduction

This section analyzes the economic impact of the second regulatory alternative which controls melting and refining emissions emanating from electric arc furnaces in the ferrous foundry industry.

The States presently have emission regulations which control particulate source emissions on the basis of process weight and/or visibility; some States even have regulations specific to electric melting or foundry facilities. It has been assumed in this study that all model plant iron EAF's and the small (3.6-Mg/h) model plant steel EAF's would have installed a side draft hood with baghouse to meet existing State regulations in the absence of any Federal regulation. Similarly, it has been assumed that the medium and large (9.1-Mg/h, 22.7-Mg/h) model plant steel EAF's would have a direct furnace evacuation system with a baghouse operating to control melting and refining emissions. It is further assumed that the second alternative can be achieved with the same control equipment required for compliance with State regulations. The additional Federal requirements over those of the States would be better maintenance of the control device and continuous monitoring of the opacity of the control device exhaust gas.

Therefore, the purpose of this section is to identify the incremental costs and impacts that would be imposed on the foundry industry and the economy by the second alternative above those already imposed by States' emission standards. Since Federal standards for water effluents and OSHA health and safety requirements are not expected to have an impact on new sources, the full impact of Federal standards on arc furnaces will be the incremental costs of those required air pollution controls that are more stringent than State regulatory requirements.

Section 8.4.2 will address potential impacts of the second alternative on foundries in regard to profitability and competition from within the industry and from imports. Any impacts on consumers due to increased product prices will be discussed in Section 8.4.3. Section 8.4.4 will present a dicussion of impacts on employment. Finally, Section 8.4.5 will cover the impacts of the regulation spanning the 5-year period after promulgation.

8.4.2 Impact on Foundries

The immediate economic impact of the second alternative would fall on newly constructed ferrous foundries with electric arc furnaces. The impact would most likely be small because the proposed alternative requires minimal capital expenditures over the baseline case, and only slight increases in operation and maintenance (O&M) expenses. Furthermore, foundries probably would not absorb the full increase in costs and, instead, would pass part or all of the costs on to the consumer. A discussion of potential impacts of the second alternative regulation on foundries regarding profitability, shifts in competitive advantage within the industry, and imports will be presented below.

8.4.2.1 Profitability. In this section, the profitability of the model plants that would be affected by the second alternative is examined in comparison with the profitability of existing sources. The determination of profitability requires information on the cost structure of the model plants chosen to depict the industry infrastructure. Based on 1979 sales and cost data, an income statement was constructed and relevant financial ratios calculated for each baseline model plant in iron and steel foundries. Development of the sales and cost figures is discussed below.

In this analysis all dollar figures were adjusted to reflect first quarter 1979 dollars. Since the cost data were presented in first quarter 1979 dollars, no adjustment of these figures was necessary. The price data, however, which were provided in 1978 dollars, were inflated upward by the producer price index for foundry and forge shop products.

Sales data were determined for each model plant by multiplying the average casting price in dollars per megagram (refer to Section 8.1, Table 8-3, which gives average casting price) by megagrams of shipments per year. Megagrams of shipments per year were calculated for each model plant (Table 8-6) by multiplying the megagrams melted per hour by hours per year by the yield of marketable castings of the annual melt rate, assumed to be 60 percent. Cost of goods sold, operating expenses, and all other expenses were estimated through the percent of sales data given in Reference 14. Total assets were calculated by applying the sales/assets ratios in Reference 14 to the sales figures. Finally, the profitability ratio for return on assets was calculated for the baseline model plants, i.e., those existing plants that have met State emission regulations but would not yet have incurred the costs required by the second alternative.

A second set of profitability calculations was generated for model plants required to comply with the second alternative. In order to evaluate the worst possible impact on the foundries, it is assumed that all costs are absorbed by the foundries. Thus, the balance sheet for the manufacturer reflects unchanged sales figures with an increase in the cost of goods sold due to incremental operating and maintenance costs. As a result of cost absorption, profitability decreases for those foundries affected by the second alternative under this worst-case scenario.

Tables 8-13, 8-14, and 8-15 show the profitability percentages of the model plants for the baseline and second alternative and the percentage reduction in profitability resulting from the second alternative. The impact on profitability is slight for all the model plants. The largest impact falls on the small (3.6-Mg/h) foundry, which undergoes a reduction in profitability after taxes from 6.0 percent to 5.4 percent, or a 9.6 percent decrease. The least affected facility is the large (22.7-Mg/h) steel foundry, in which aftertax profits decrease 1.0 percent below the baseline alternative.

The above analysis is not intended to show that profitability would decrease by the amounts calculated in Tables 8-14 and 8-15. These calculations instead indicate the maximum profitability impact that new foundries would experience relative to existing sources. It is likely that some small new foundries competing with small existing foundries will absorb at least a portion of the costs of the second alternative to remain competitive, and likewise for medium and large-sized foundries.

TABLE 8-13. DERIVED INCOME STATEMENT AND BALANCE SHEET DATA FOR BASELINE MODEL PLANTS[a]

	Furnace size (Mg/h)		
	3.6	9.1	22.7
Shipments (Mg/yr)	3,460	10,480	38,140
Income statement			
Sales ($943.0/Mg)[b]	$3,263,000	$9,883,000	$35,966,000
Cost of goods sold[c]	2,522,000	7,758,000	29,312,000
Gross profit	741,000	2,125,000	6,654,000
Operating expenses[d]	626,000	1,443,000	4,028,000
Operating profit	115,000	682,000	2,626,000
All other expenses[d]	-7,000	119,000	396,000
Profit before taxes	122,000	563,000	2,230,000
Profit after taxes[e]	85,000	323,000	1,223,000
Balance sheet			
Sales/total assets ratio[f]	2.31	2.00	1.51
Total assets[g]	$1,413,000	$4,942,000	$23,819,000
Percent profit before taxes/ total assets	8.6	11.4	9.4
Percent profit after taxes/ total assets	6.0	6.5	5.1

[a] All dollars are in first quarter 1979 dollars.

[b] Sales determined by multiplying average casting price in dollars per megagram times megagrams of shipments per year. Shipments are calculated by multiplying the operating rates (Mg/yr) from Table 8-6 by the yield of 60 percent.

[c] Cost of goods sold determined from percent of sales data found in Reference 14. Each model plant is identified with one of the three asset size categories in Reference 14 based on volume of sales. The percentages associated with that category are applied to the sales figures, which were derived externally for each model plant.

TABLE 8-13. DERIVED INCOME STATEMENT AND BALANCE SHEET DATA FOR BASELINE MODEL PLANTS[a]

(concluded)

---

[d] Operating expenses and all other expenses determined by percent of sales method. Percentages for each model plant are obtained from Reference 14 as described above in footnote c.

[e] Taxes calculated at following rates: first \$25,000--17 percent; second \$25,000--20 percent; third \$25,000--30 percent; fourth \$25,000--40 percent; over \$100,000--46 percent.[15]

[f] Sales/assets ratios for each model plant were calculated from the sales and assets figures in the appropriate asset-size category in Reference 14. See footnote c above.

[g] Total assets calculated by dividing sales by sales/assets ratios.

TABLE 8-14. PROFITABILITY IMPACT ANALYSIS FOR IRON MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a,b]

	Furnace size (Mg/h)		
	3.6	9.1	22.7
Shipments (Mg/yr)	3,460	10,480	38,140
Income statement			
Sales	$3,263,000	$9,883,000	$35,966,000
Cost of goods sold[c]	2,535,500	7,779,100	29,348,000
Gross profit	727,500	2,103,900	6,618,000
Operating expenses	626,000	1,443,000	4,028,000
Operating profit	101,500	660,900	2,590,000
All other expenses	-7,000	119,000	396,000
Profit before taxes	108,500	541,900	2,194,000
Profit after taxes	77,800	312,000	1,204,000
Balance sheet			
Total assets[d]	$1,431,000	$4,961,000	$23,839,000
Percent profit before taxes/ total assets	7.6	10.9	9.2
Percent profit after taxes/ total assets	5.4	6.3	5.0
Percent reduction in return on assets (after taxes)[e]	9.6	3.8	1.6

[a] All dollars are in first quarter 1979 dollars.

[b] See footnotes in Table 8-13 for explanation of how numbers were derived.

[c] Cost of goods sold for the second alternative are equal to cost of goods sold in the baseline case plus the incremental annualized costs of pollution control devices to meet the second alternative. Incremental costs for the 3.6-Mg/h (4-ton/h) iron foundry equal $13,500; for the 9.1-Mg/h (10-ton/h) iron foundry, $21,100; and for the 22.7-Mg/h (25-ton/h) iron foundry, $36,000. Refer to Table 8-10 for breakdown of cost figures.

TABLE 8-14. PROFITABILITY IMPACT ANALYSIS FOR IRON MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a,b]

(concluded)

---

[d] Assets for the second alternative increase by the amount of the capital costs of the continuous opacity monitors. These costs for the 3.6 Mg/h iron foundry equal $18,000; for the 9.1 Mg/h iron foundry, $19,000; and for the 22.7 Mg/h iron foundry, $20,000.

[e] Calculations were carried out retaining three significant digits in "percent profits after taxes/total assets."

TABLE 8-15. PROFITABILITY IMPACT ANALYSIS FOR STEEL MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a,b]

	Furnace size (Mg/h)		
	3.6	9.1	22.7
Shipments (Mg/yr)	3,460	10,480	38,140
Income statement			
Sales	$3,263,000	$9,883,000	$35,966,000
Cost of goods sold[c]	2,535,500	7,770,700	29,331,100
Gross profit	727,500	2,112,300	6,632,900
Operating expenses	626,000	1,443,000	4,028,000
Operating profit	101,500	669,300	2,604,900
All other expenses	-7,000	119,000	396,000
Profit before taxes	108,500	550,300	2,208,900
Profit after taxes	77,800	316,000	1,212,000
Balance sheet			
Total assets[d]	$1,431,000	$4,961,000	$23,839,000
Percent profit before taxes/ total assets	7.6	11.1	9.3
Percent profit after taxes/ total assets	5.4	6.4	5.1
Percent reduction in return on assets (after taxes)[e]	9.6	2.6	1.0

[a] All dollars are in first quarter 1979 dollars.

[b] See footnotes in Table 8-13 for explanation of how numbers were derived.

[c] Costs of goods sold for the second alternative equal the baseline costs plus the incremental costs resulting from the second alternative. Incremental annualized costs for the 3.6-Mg/h (4-ton/h) steel foundry are $13,500; for the 9.1-Mg/h (10-ton/h) steel foundry, $12,700; for the 22.7-Mg/h (25-ton/h) steel foundry, $21,100.

TABLE 8-15. PROFITABILITY IMPACT ANALYSIS FOR STEEL MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a,b] (concluded)

---

[d] Assets for the second alternative increase by the amount of the capital costs of the continuous opacity monitors. These costs for the 3.6 Mg/h steel foundry equal $18,000; for the 9.1-Mg/h steel foundry, $19,000; and for the 22.7-Mg/h steel foundry, $20,000.

[e] Calculations were carried out retaining three significant digits in "percent profits after tax/total assets."

However, the facts that many foundries have specialized markets, that the industry is near capacity, and that demand for castings exhibits price inelasticity all support the hypothesis that foundries may be able to pass some costs through to the consumer.

Foundries produce a wide variety of castings, many of which are designed specifically to a customer's needs. For those castings which are unique, producers may be able to mark up casting prices and thereby pass the incremental pollutions costs on to the consumer. Cost passthrough may also occur when the foundry industry is at or near full capacity. A survey of foundrymen indicated that foundries were operating at about 82 percent of capacity in 1978, a figure that comes close to the 85 to 90 percent at which most foundries feel they are at a realistic maximum.[16] Lastly, passthrough of costs may occur where demand for a product is fairly inelastic, since price increases will not result in a loss of revenue. Castings in the aggregate appear to be price inelastic for consumers of castings as measured against the producer price index. This is supported by the fact that castings prices during the last several years have been rising faster than the producer price index. Along with higher prices, volumes of shipments have been increasing.

In the absence of additional data, such as demand elasticities for castings, it can only be concluded that the model plants under the second alternative would suffer profit losses anywhere between 0 percent (full cost passthrough) and 9 percent (full cost absorption in the small-size iron foundry model plant).

8.4.2.2 Shifts in Competitive Advantage Within the Foundry Industry. Since the magnitude of the cost increases imposed by the second alternative are so small, it is not expected that any discernable shifts in competitive advantage among foundries would occur. Furthermore, differences in castings products and the production methods to create the castings have resulted in market segmentation, limiting at the outset competition among foundries of differing sizes.

Large foundries with standardized, highly mechanized production methods can operate profitably only with large volumes of orders. Unit production costs are low on large-scale production, predominantly reflecting melting costs. Pattern and mold costs are low because of standardized patterns and automated machinery capable of high output. Small foundries, on the other hand, are less capital and more labor intensive. These foundries produce specialty castings made to specific buyer needs. For small volume orders of specialty castings, the cost is strongly influenced by the cost of core and mold making, with much of the cost resulting from the specialized experience of individual foundrymen to produce a casting more or less handmade according to specifications.

Because of the differences in production methods, large jobbing foundries for the most part compete with large foundries. Similarly, small jobbing foundries compete with small foundries. However, small foundries may compete with a larger foundry for certain orders, where the cost structure becomes marginal for the large foundry. Any limited competition that exists as such may be reduced since the small iron and steel foundries face higher percentage cost increases due to the second alternative than do the large size foundries. As indicated earlier, any shifts in competitive advantage toward the large foundries would be slight.

The last issue to be addressed here is whether or not the incremental costs of the second alternative would lead to delays in plant construction. It can be concluded that any firm which is able to raise the capital to build a new facility would also be able to finance the incremental costs of the second alternative. First of all, there would be minimal capital requirements resulting from the second alternative. Based on data for the six model plants, the cost of the continuous opacity monitors would comprise one percent or less of the base cost of installing electric arc furnaces in a foundry. Secondly, the O&M costs of the second alternative would represent a small fraction of total operating costs of the model plants studied. Calculations show that the annual incremental O&M costs due to the second alternative range from a low of 0.4 percent to a high of 1.7 percent of the total operating expenses in the six model plants. Since the cost requirements of the second alternative involve only minimal capital expenditures and operating costs, no delay in plant construction will result should the second alternative be adopted.

8.4.2.3 Imports. In 1978 exports of iron and steel castings were 2 percent of the value of all domestic shipments of ferrous castings, and imports were 1 percent of that value, as stated in Section 8.1.2.3. These percentages have stayed relatively constant over the past 10 years. Although the importation of castings is small in volume and the balance of trade in castings is favorable to the U.S., some imported castings may have an impact on domestic foundries. For instance, 34 percent of U.S. purchased cast steel valves were imported in 1977.[17] A sampling of steel foundry sales executives in 1978 revealed that respondents had lost sales to importers for such castings as valve bodies, pump cases and related fittings, and large hydraulic turbine castings.[18] According to the foundry executives, foundries have lost out to imports because of price differentials, with foreign competitors undercutting domestic producers' bid prices by an average of 30 percent.[18]

The imported castings are predominantly standardized, large volume production castings coming from Japan and other Far East nations, where costs of production have been reduced through mechanization and high efficiency. Few specialty castings are imported because casting designs are frequently changed following delivery of samples to the buyer. Frequent monitoring of casting design, casting scrap, and the production of castings tends to limit international trade and instead encourage a close geographical location of specialty casting producers and buyers.

Import competition will continue to exist regardless of enactment of Federal regulations. The second alternative, however, should lead neither to increased imports nor profitability impacts on domestic foundries from import competition.

Imported castings, as discussed above, are large production, standardized castings which would compete with domestic castings produced in large foundries, typified in this analysis by the 22.7-Mg/h model plant. It is in the large foundries that the incremental costs of the second alternative begin to disappear; they become a very small fraction of total operating costs. The costs of the second alternative comprise 0.8 percent of operating expenses in the 22.7-Mg/h iron foundry model plant and 0.4 percent of operating expenses in the 22.7-Mg/h steel foundry model plant. These costs, if incurred, would represent less than a 2 percent reduction in return on assets for both model plants.

It is assumed that a new foundry would be more highly automated and more efficient than the older foundries, thus resulting in lower costs per unit of output. Lower costs translated into lower prices should serve to dampen imports. The slight increase in production costs resulting from the second alternative would be insignificant in comparison with savings accrued from building a new plant.

8.4.3 Impact on Product Prices

Due to the second alternative, consumers could be impacted by higher prices as foundries partially or fully pass the costs of pollution control on to the consumer. A worst case analysis, which assumes full passthrough of costs, is used here to demonstrate the maximum degree to which consumers would be impacted. The method for determining these price increases and a discussion of the significance of the increases is given below.

In Table 8-13, income statements were constructed for each baseline model plant in iron and steel foundries based on externally calculated sales values, which were then multiplied by percent of sales data found in Reference 13. The baseline alternative assumes that the model plants have sufficient pollution controls to meet the baseline State regulations but that the plants have not yet incurred the expenses of the second alternative.

In Tables 8-16 and 8-17, new sales figures are calculated which reflect the level of sales required for foundries to obtain their baseline return on investment. In these tables, profits after tax are first determined from the baseline assets and return and investment figures. Profit after tax and total costs under the second alternative are summed to determine sales. The new sales figures, divided by shipments, yield the average castings prices that foundries would charge customers under a full cost passthrough scenario. By comparing prices under the baseline and second alternatives, the cost passthrough and percent price increases are then calculated.

In order to determine the price of castings for the baseline case against which to measure the price increases resulting from the second alternative, an average castings price ($/Mg) for the industry was calculated. This method was chosen because pricing information on individual castings is unavailable. The average price in first quarter

TABLE 8-16. PRICE IMPACT ANALYSIS FOR IRON MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a]

	Furnace size (Mg/h)		
	3.6	9.1	22.7
Shipments (Mg/yr)	3,460	10,480	38,140
Income statement			
Sales ($943.00/Mg)[b]	$3,277,850	$9,902,600	$35,987,800
Total costs[c]	3,154,500	9,341,100	33,772,000
Profit before taxes[d]	123,350	561,520	2,215,810
Profit after taxes[e]	85,860	322,470	1,215,790
Balance sheets[f]			
Total assets	$1,431,000	$4,961,000	$23,839,000
Percent profit before taxes/total assets	8.6	11.4	9.4
Percent profit after taxes/total assets	6.0	6.5	5.1
Price after NSPS	$ 947.40	$ 944.90	$ 943.60
Cost passthrough	4.40	1.90	0.60
Percent price increase	0.47	0.20	0.06

[a] All dollars are in first quarter 1979 dollars.

[b] The sales figures calculated reflect the required level of sales for the plant to retain its baseline return on investment. Sales are calculated by summing total costs and profit before taxes.

[c] Total costs include the costs of goods sold, operating expenses, and all other expenses, as determined for the second alternative. Refer to Table 8-14 for cost figures.

[d] Profit before tax is back-calculated after profit after tax is determined.

[e] Profit after tax is calculated by multiplying total assets by the return on investment (percent profit after taxes/total assets).

[f] Total assets are derived in Table 8-14, while percent profit before taxes/total assets and percent profit after taxes/total assets are derived in Table 8-13.

TABLE 8-17. PRICE IMPACT ANALYSIS FOR STEEL MODEL PLANTS MEETING REQUIREMENTS OF SECOND ALTERNATIVE[a]

	Furnace size (Mg/h)		
	3.6	9.1	22.7
Shipments (Mg/yr)	3,460	10,480	38,140
Income statement			
Sales ($943.00/Mg)[b]	$3,277,850	$9,894,220	$35,970,000
Total costs	3,154,500	9,332,700	33,755,000
Profit before taxes[d]	123,350	561,520	2,215,800
Profit after taxes[e]	85,860	322,470	1,215,790
Balance sheets[f]			
Total assets	$1,431,000	$4,961,000	$23,839,000
Percent profit before taxes/total assets	8.6	11.4	9.4
Percent profit after taxes/total assets	6.0	6.5	5.1
Price after NSPS	$ 947.40	$ 944.90	$ 943.10
Cost passthrough	4.40	1.10	0.10
Percent price increase	0.47	0.12	0.01

[a] All dollars are in first quarter 1979 dollars.

[b] The sales figures calculated reflect the required level of sales for the plant to retain its baseline return on investment. Sales are calculated by summing total costs and profit before taxes.

[c] Total costs include the costs of goods sold, operating expenses, and all other expenses, as determined for the second alternative. Refer to Table 8-15 for cost figures.

[d] Profit before tax is back-calculated after profit after tax is determined.

[e] Profit after tax is calculated by multiplying total assets by the return on investment (percent profit after taxes/total assets).

[f] Total assets are derived in Table 8-15, while percent profit before taxes/total assets and percent profit after taxes/total assets are derived in Table 8-13.

1979 dollars ($943.01/Mg or $855.3/ton) was calculated by dividing 1978 total industry value of shipments by volume of shipments and adjusting the figure upward to reflect first quarter 1979 dollars.

In actuality, product pricing is negotiated on a per piece basis rather than a cents per pound basis for good castings (i.e., the material the customer receives rather than the metal poured). The unit price will be dependent upon the volume of an individual order, the requirements for the core and mold, and the desired precision and quality of the casting itself. For unique castings produced predominately in small jobber foundries, the price will be highly sensitive to the cost of pattern, core, and mold preparation. For large production and standardized molds and cores, the price of castings may not be much more than the melting cost. This is the case in assembly line production foundries or in captive foundries. Therefore, the average castings price per ton calculated above may be understated for specialty castings and overstated for large volume, standardized castings.

Returning to the income statement and balance sheet items, calculations show that under full cost passthrough prices would rise a minimum of 0.01 percent in the large-size steel foundry and a maximum of 0.47 percent in the small iron and steel foundries. These percentage increases are insignificant, especially when compared against the producer price index for iron and steel products, which rose from 230.4 in 1977 to 253.6 in 1978.[19-25]

8.4.4 Employment

The proposed alternative for the iron and steel foundry industry would have no effect on employment within the industry because it is assumed that there will be no delay in plant construction as a result of the alternative.

8.5 POTENTIAL SOCIOECONOMIC IMPACTS

The purpose of this section is to review the fifth year impacts that would arise under the second alternative and to determine if any of the criteria for a regulatory (significant action) analysis are triggered.

Summarized below are the aggregate economic impacts which would occur 5 years after the NSPS is imposed, including total annualized costs, inflationary impact on the price of castings, and changes in energy consumption. Annualized costs of the second alternative in the fifth year would be no greater than $3.5 million, which represents the costs of incremental capital and operations and maintenance expenses. Total industry annualized costs for the year 1983 were determined by multiplying the number of new plants expected to come on line in the next 5 years by the annualized costs per plant. It was assumed here under a worst-case hypothesis that all new plants would be the small 3.6-Mg/h foundries since these foundries have the highest annualized costs as a percentage of total costs. The expected increase in capacity for the industry between 1978 and 1983 (see Table 8-4) is divided by the megagrams per year capacity for the 3.6-Mg/h foundries (see Table 8-6) to obtain the estimated number of new plants. This figure is multiplied by the increased costs ($13,500/yr) that would be incurred by the small foundries as a result of the second alternative.

The potential price increase in the fifth year would be $0.17/Mg, which is a 0.02 percent over the average castings price in the first quarter of 1977. The dollar per megagram increase is calculated by dividing the 5-year annualized cost figure given above by the projected volume of shipments in 1983. This calculation gives dollar per megagram increases resulting from the second alternative affecting new sources coming on line within the next 5 years.

Energy consumption in the foundry industry would not be affected by the second alternative. This is because the additional requirements of the second alternative over the baseline, better maintenance and continuous monitoring, would result in a negligible energy usage change over the baseline level.

The issues covered in Section 8.4 demonstrate that no macroeconomic or socioeconomic impacts will result from the proposed alternative. Likewise, as indicated below, no significant action analysis will be required. The criteria which would trigger a significant action analysis are enumerated below:

1. Additional annualized costs of compliance totaling $100 million within 5 years of implementation of the NSPS.
2. Additional production costs exceeding 5 percent of the selling price of the product.

3. Net national energy consumption increasing by the equivalent of 25,000 barrels of oil per day.

None of the these guidelines will be exceeded as a result of the second alternative. Annualized costs of compliance over the 5-year period would only rise to $3.5 million, additional productions costs would be considerably under 1 percent of the selling price of castings, and national energy consumption would remain the same.

8.6 REFERENCES FOR CHAPTER 8

1. Foundry Management and Technology. Metal Casting Industry Census Guide, 1979 edition. Cleveland. April 1979. 64 p.

2. Davis, J. A., E. E. Fletcher, R. L. Wenk, and A. R. Elsea. Screening Study on Cupolas and Electric Furnaces in Gray Iron Foundries. Final Report. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Contract No. 68-01-0611, Task No. 8. August 1975.

3. Steel Founders' Society of America. Directory of Steel Foundries in the United States, Canada, and Mexico, 1977-78. Rocky River, Ohio. 1977. 274 p.

4. 1979 U.S. Industrial Outlook. U.S. Department of Commerce, Industry and Trade Administration. Washington, D.C. January 1979. p. 178-179.

5. The Foundry Industry--A Look Ahead. Foundry Management and Technology. p. 38-48. January 1978.

6. Gaultier, M. Have You Been to the Market Lately. Modern Casting. 65(9):46-47. September 1976.

7. Foundrymen Forecast 9.1% Increase. Foundry Management and Technology. p. 32. January 1978.

8. Letter from Eliason, C. R., Union Carbide Corporation, Carbide Products Division, to Maxwell, W. H., Midwest Research Institute. April 18, 1979. Response to questionnaire on foundry EAF units.

9. Economic Indicators. Chemical Engineering. 86(14):7. July 2, 1979.

10. Fennelly, P. F. and P. D. Spawn. Air Pollutant Control Techniques for Electric Arc Furnaces in the Iron and Steel Foundry Industry. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Publication No. EPA-450/2-78-024. (OAQPS No. 1.2-099). June 1978. 215 p.

11. Davis, J. A., C. S. DuMont, E. E. Fletcher, and A. R. Elsea. Economic Impact of the Proposed New-Source-Performance Standards Upon Construction of Arc Furnaces in the Gray Iron Foundry Industry. Final Report. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Contract No. 68-02-1323, Task No. 28. August 1975. p. 8-36 to 8-41.

12. Development Document for Effluent Limitations Guidelines and New Source Performance Standards: Iron and Steel Foundry Industry. Draft Report. U.S. Environmental Protection Agency, Research Triangle Park, N.C. Contract No. 68-01-1507. July 1974. p. 71-72, 96-97, 132, 139.

13. Memo and attachment from Pahl, D.A., EPA, to the Files. March 13, 1980. Basis for estimation of hazardous waste hauling and disposal costs.

14. '78 Annual Statement Studies. Robert Morris Associates. Philadelphia, Pa. 1978. p. 76.

15. United States Congress. Internal Revenue Code. Income, Estate and Gift Tax Provisions. Chicago, Ill. Commerce Clearing House, Inc. January, 1979. p. XIV.

16. Late News. Foundry Management and Technology. p. 9. January 1979.

17. Imported Castings: A Status Report. Foundry Management and Technology. p. 26-32. December 1977.

18. Steelmen Measure Inroads by Imports. American Metal Market. p. 10A. April 21, 1978.

19. Statistical Abstract of the United States: 1978. 99th Annual Edition. U.S. Department of Commerce. Bureau of the Census. Washington, D.C. September 1978. p. 486.

20. Producer Prices and Price Indexes. Data for May 1978. U.S. Department of Labor. Bureau of Labor Statistics. Washington, D.C. July 1978. p. 33.

21. Producer Prices and Price Indexes. Data for June 1978. U.S. Department of Labor. Bureau of Labor Statistics. Washington, D.C. August 1978. p. 38.

22. Producer Prices and Price Indexes. Data for July 1978. U.S. Department of Labor. Bureau of Labor Statistics. Washington, D.C. October 1978. p. 38.

23. Producer Prices and Price Indexes. Data for September 1978. U.S. Department of Labor. Bureau of Labor Statistics. Washington D.C. November 1978. p. 34.

24. Producer Prices and Price Indexes. Data for November 1978. U.S. Department of Labor. Bureau of Labor Statistics. Washington, D.C. January 1979. p. 34.

25. Producer Prices and Price Indexes. Data for January 1979. U.S. Department of Labor. Bureau of Labor Statistics. Washington, D.C. March 1979. p. 37.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Date	Company, consultant, or agency	Location	Nature of action
1-28-74	Ford Motor Co. Pontiac Motors Div. U.S. Steel Corp.	Flat Rock, MI Pontiac, MI Pittsburgh, PA	Section 114 letter.
2-4-74	Gleason Works	Rochester, NY	Section 114 letter.
2-13-74	Gray and Ductile Iron Founders' Society	Rocky River, OH	Meeting to discuss air pollution problems in gray iron foundry industry.
3-5-74	John Deere Corp. DeLaval Turbine, Inc.	East Moline, IL Oakland, CA	Section 114 letter.
3-11-74	Lectromelt Division, Pennsylvania Engr. Corp.	Pittsburgh, PA	Meeting to discuss EAF air pollution control.
3-12-74	Swindell-Dressler Co.	Pittsburg, PA	Meeting to discuss EAF air pollution control.
3-13-74	John Deere Corp.	Waterloo, IA	Pretest survey.
3-14-74	John Deere Corp.	East Moline, IL	Pretest survey.
3-29-74	Ford Motor Co. General Motors Corp.	Flat Rock, MI Warren, MI	Section 114 letter.
4-1-74	Brown Boveri Corp.	N. Brunswick, NJ	Meeting to discuss industry growth and EAF's.
4-9-74	Ford Motor Co.	Flat Rock, MI	Pretest survey.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT (continued)

Date	Company, consultant, or agency	Location	Nature of action
4-10-74	General Motors Corp. Pontiac Division	Warren, MI Pontiac, MI	Pretest survey.
4-18-74	Gleason Works	Rochester, NY	Section 114 letter.
5-1-74	American Foundrymen's Society	Des Plaines, IL	Meeting to discuss testing locations, economics, and industry growth.
5-15-74	Hayes-Albion Corp.	Albion, MI	Pretest survey.
5-24-74	Gray and Ductile Iron Founders' Society	Rocky River, OH	Letter requesting EAF information.
6-4-74	Paxton-Mitchell Co.	Omaha, NE	Pretest survey.
6-20-74	John Deere Corp.	Waterloo, IA	Field test of EAF.
7-11-74	John Deere Corp.	East Moline, IL	Field test of EAF.
7-22-74	EPA	Durham, NC	Test recommendations made for Gleason Works and Paxton-Mitchell.
9-19-74	Gleason Works	Rochester, NY	Field test of EAF.
10-4-74	Paxton-Mitchell	Omaha, NE	Field test of EAF.
1-10-75	Lectromelt Division, Pennsylvania Engr. Corp. Swindell-Dressler Co.	Pittsburgh, PA	Meeting to discuss canopy hood sizing.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT (continued)

Date	Company, consultant, or agency	Location	Nature of action
9-2-75	Western Precipitation	Pittsburgh, PA	Letter requesting EAF ESP information.
9-11-75	Obenchain Calumet	Gary, IN	Letter requesting EAF total enclosure information.
11-75	EPA	Durham, NC	Draft SSEIS.
12-19-75	NAPCTAC	Raleigh, NC	Meeting to discuss proposed NSPS.
2-2-76	General Motors Corp.	Warren, MI	Letter confirming visit.
2-13-76	Pontiac Motors Division	Pontiac, MI	Plant visit to observe building evacuation system.
	American Waagner-Biro	Pittsburgh, PA	Meeting to discuss preheaters.
4-6-76	Dresser Mfg. Co.	Anniston, AL	Plant visit to observe charging of preheated scrap.
5-4-76	American Steel Foundries	Chicago, IL	Letter requesting EAF emission data.
5-5-76	Blaw-Knox, Inc.	East Chicago, IN	Letter requesting EAF information.
5-7-76	Fort Pitt Steel Casting	McKeesport, PA	Letter confirming visit.
5-13-76	General Motors Corp.	Warren, MI	Letter requesting EAF emission control data.
5-26-76	American Steel Foundries	Chicago, IL	Section 114 letter.
6-1-76	Blaw-Knox, Inc.	East Chicago, IN	Section 114 letter.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT
(continued)

Date	Company, consultant, or agency	Location	Nature of action
10-76	EPA	Durham, NC	Draft SSEIS (unpublished).
12-76	EPA	Durham, NC	Draft addendum to SSEIS (unpublished).
9-14-77	Lone Star Steel Corp.	Lone Star, TX	Plant visit to observe EAF total enclosure.
9-16-77	Hensley Industries	Dallas, TX	Plant visit to observe close capture system.
9-30-77	Joy Manufacturing Co.	Claremont, NH	Plant visit to observe close capture system.
6-78	EPA	Durham, NC	CTG document published.
4-6-79	Cast Metals Federation	Rocky River, OH	Letter requesting EAF and industry information.
	Iron Casting Society		
	Steel Founders' Society of America		
	National Foundry Association	Westchester, IL	
	Ductile Iron Society	Mountainside, NJ	
	Iron and Steel Society	Warrendale, PA	
	American Foundrymen's Society	Des Plaines, IL	
	Penton Publications	Cleveland, OH	
4-9-79	Great Lakes Carbon Corp.	Niagra Falls, NY	Letter requesting EAF and industry information.
	Lectromelt Corp.	Pittsburgh, PA	
	Whiting Corp.	Harvey, IL	
	Union Carbide Corp.	New York, NY	
	Foundry Supply Mfg. Group	Pittsburgh, PA	
	Foundry Equipment Mfg. Assoc.	Washington, DC	
	Hawley Mfg. Corp.	Indianapolis, IN	Letter requesting EAF control and industry information.
	Obenchain Calumet	Gary, IN	
	Pennsylvania Engr. Corp.	Pittsburgh, PA	

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT (concluded)

Date	Company, consultant, or agency	Location	Nature of action
4-19-79	ARMCo, National Supply Div.	Torrance, CA	Section 114 letter.
5-2-79	Joy Manufacturing Co. Northern Steel Castings, Inc.	Claremont, NH Wisconsin Rpds., WI	Section 114 letter.
5-8-79	Lone Star Steel Co.	Lone Star, TX	Section 114 letter.
5-31-79	ARMCo, National Supply Div.	Torrance, CA	Plant visit to observe EAF tapping pit enclosure.
6-8-79	Lone Star Steel Co.	Lone Star, TX	Plant visit to observe EAF total enclosure.
7-12-79	Certified Alloy Prod., Inc.	Long Beach, CA	Section 114 letter.
1-80	EPA	Durham, NC	Draft BID.
2-28-80	NAPCTAC	Raleigh, NC	Meeting to discuss recommended NSPS.
4-80	EPA	Durham, NC	Draft BID.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system, cross-indexed with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of environmental impact statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

TABLE B-1. CROSS-INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
1. BACKGROUND AND SUMMARY OF REGULATORY ALTERNATIVES	
Summary of regulatory alternatives	The regulatory alternatives from which standards will be chosen for proposal are summarized in Chapter 1, Section 1.1.
Statutory basis for proposing standards	The statutory basis for proposing standards is summarized in Chapter 2, Section 2.1.
Relationship to other regulatory agency actions	The relationships between the regulatory agency actions are summarized in Chapter 8, Section 8.3.
Industry affected by the regulatory alternatives	A discussion of the industry affected by the regulatory alternatives is presented in Chapter 3, Section 3.1. Further details covering the business and economic nature of the industry are presented in Chapter 8, Section 8.1.
Specific processes affected by the regulatory alternatives	The specific processes and facilities affected by the regulatory alternatives are summarized in Chapter 1, Section 1.1. A detailed technical discussion of the processes affected by the regulatory alternatives is presented in Chapter 3, Section 3.2.
2. REGULATORY ALTERNATIVES	
Control techniques	The alternative control techniques are discussed in Chapter 4, Sections 4.2, 4.3, and 4.4.

TABLE B-1. CROSS-INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT (concluded)

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
Regulatory alternatives	The various regulatory alternatives, including "no additional regulatory action," are defined in Chapter 6, Section 6.3. A summary of the major alternatives considered is included in Chapter 1, Section 1.3.
3. ENVIRONMENTAL IMPACT OF THE REGULATORY ALTERNATIVES	
Primary impacts directly attributable to the regulatory alternatives	The primary impacts on mass emissions and ambient air quality due to the alternative control systems are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5. A matrix summarizing the environmental impacts is included in Chapter 1.
Secondary or induced impacts	Secondary impacts for the various regulatory alternatives are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5.
4. OTHER CONSIDERATIONS	A summary of the potential adverse environmental impacts associated with the regulatory alternatives is included in Chapter 1, Section 1.2, and Chapter 7. Potential socioeconomic and inflationary impacts are discussed in Chapter 8, Section 8.5. Irreversible and irretrievable commitments of resources are discussed in Chapter 7, Section 7.6.

APPENDIX C

EMISSION TEST DATA FOR FABRIC FILTERS ON ELECTRIC ARC FURNACES AT IRON AND STEEL FOUNDRIES

This appendix presents the emission test data for iron and steel electric arc furnaces (EAF's) which were summarized in Section 4.6. Section C.1 presents the results of particulate and gaseous sampling and visible emission observations conducted by EPA at four iron foundries and data obtained from two other foundries. Section C.2 presents data concerning steel foundry particulate emissions. Section C.3 presents visible emission data from observations made by EPA observers at two steel-producing foundries. Section C.4 presents the results of visible emission observations of a tapping pit capture device at a steel foundry. Summary tables presenting the data for each individual plant follow Section C.4.

C.1 EMISSION LEVELS FROM FABRIC FILTERS AT IRON ELECTRIC ARC FURNACES

C.1.1 Particulate and Visible Emissions

The following discussion summarizes results of emission sampling conducted on baghouses installed on EAF's at six gray iron foundries. Analyses were conducted for both particulate and gaseous pollutants. The concentration of particulate emissions was measured by EPA Reference Method 5. Each test consisted of sampling in the baghouse exhaust stack, downstream of the baghouse and exhaust fans. The visible emission observations were made using EPA Reference Method 9. The particulate and visible emissions data are summarized in Figure C-1 and Table C-1, respectively. The data for Plants A, B, C, and D were obtained during field tests by EPA contractors while those for Plants E and F were submitted by outside sources.

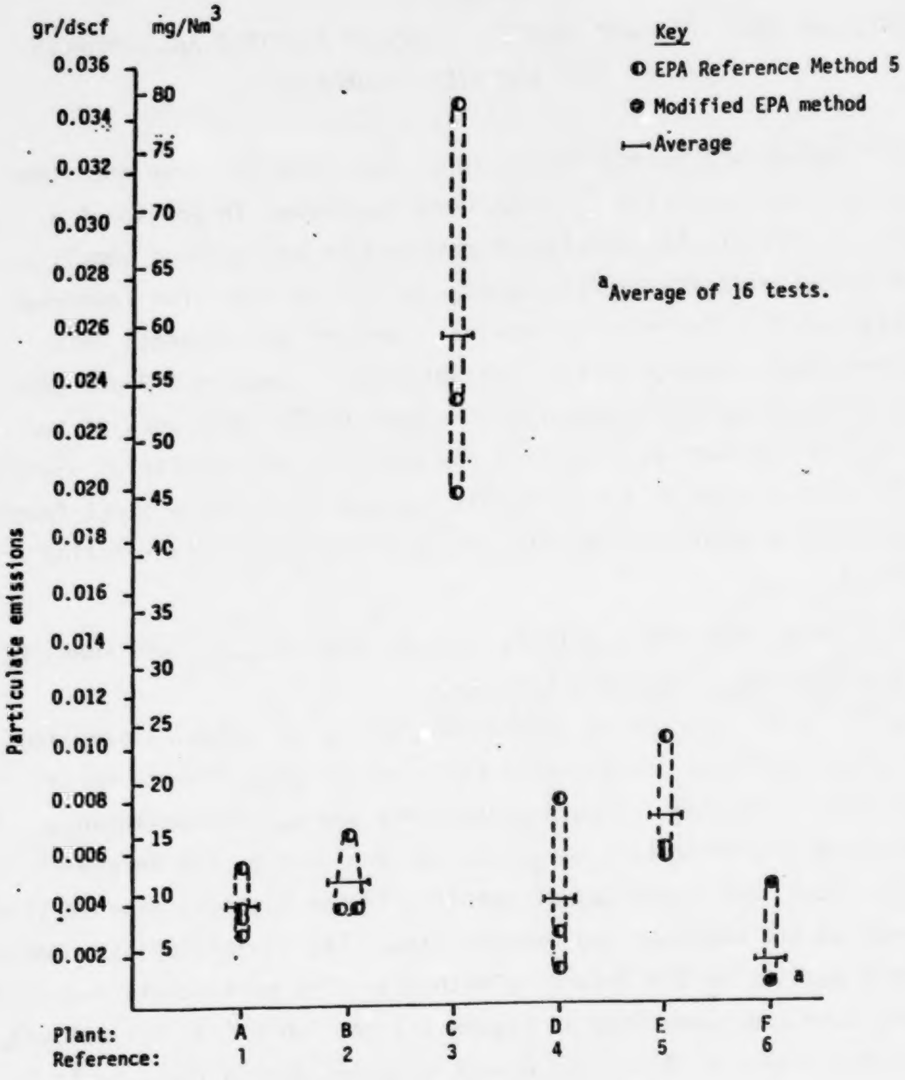


Figure C-1. Summary of source test data for baghouses on EAF's producing iron.

TABLE C-1. SUMMARY OF VISIBLE EMISSION DATA FOR EAF'S PRODUCING IRON (6-minute average)

	Stack		Roof vent	
Plant	Maximum	Percent of time ≦ 10%	Maximum	Percent of time ≦ 10%
A[1]	9.6	100	10.4	99
B[2]	11.5	99	2.3	100
C[3]	30.4	87	--	--
D[4]	5.0	100	7.3	100

C.1.1.1 Plant A. Plant A has three arc furnaces of 13 to 15 Mg (14 to 16 tons) melting capacity each.[1] Two automatically shaken baghouses are used for exhaust gas cleaning. Two furnaces are exhausted to one baghouse, and a third furnace is exhausted to the second baghouse. Each furnace is equipped with a side draft hood and with hoods above the pouring spout and the slag door for emission capture. The three hoods from each furnace are connected to a common duct which is under suction from the baghouse centrifugal fan. Overhead roof fans and monitors ventilate the furnace scrap bays and also withdraw a small amount of air from adjacent areas. An open-ended duct [1.5 m (5 ft) in diameter] is located about 13 m (43 ft) above each furnace. These ducts are not canopy-type hoods but extend down from the roof area toward each furnace and are used only during charging and tapping of the furnace. The ducts are connected to the same baghouse as the other furnace hoods. Since a canopy hood is not used, complete control of charging and tapping emissions is not provided. The baghouses are equipped with Dacron* filter bags which withstand a maximum temperature of 135°C (275°F) and have an air-to-cloth ratio of 2.5:1.

The baghouse which controls two furnaces (Nos. 1 and 2) was tested. The exhaust gases at the baghouse inlet and outlet were sampled simultaneously for particulates, carbon monoxide [using a nondispersive infrared (NDIR) analyzer], hydrocarbons (using a Beckman Hydrocarbon Analyzer*), sulfur dioxide (by EPA Reference Method 6), and nitrogen oxides (by EPA Reference Method 7). Both furnaces were performing at design capacity during the tests, and the emission control system appeared to be operating well. The exhaust gas flow rate averaged 76.1 (dscm/min)/Mg of iron produced (2,445 dscfm/ton).[+] Each sample period commenced with the beginning of a heat on one of the furnaces and continued for approximately 3 hours. Generally, the furnaces were on a staggered schedule. An average heat lasted about 70 minutes, and a sampling period encompassed at least two full heats on each furnace. A "heat" encompasses the time from the beginning of charging to the end of the tapping of molten metal.

---

*Mention of trade names does not constitute endorsement by EPA.

[+] (dscm/min)/Mg = dry standard cubic meters per minute per megagram. dscfm/ton = dry standard cubic feet per minute per ton.

Detailed results of the tests are presented in Tables C-3 and C-4. The outlet particulate concentrations determined from the four samples were 8.7, 8.0, 6.5, and 12.3 mg/dscm (0.0038, 0.0035, 0.0028, and 0.0054 gr/dscf),* for an average of 8.9 mg/dscm (0.0039 gr/dscf).

Concurrent with baghouse sampling, visible emission data were obtained for the baghouse stack and for the roof monitor above the furnaces. The results are presented in Tables C-11 through C-18. The highest opacity (6-minute average) observed from the baghouse stack during the nearly 15 hours that readings were taken was 9.6 percent. The opacity (6-minute average) was 5 percent or less about 90 percent of the time. At the roof monitor, the maximum 6-minute average opacity was 10.4 percent, and the opacity (6-minute average) was 5 percent or less about 95 percent of the time.

C.1.1.2 Plant B. Plant B is a foundry with four electric arc furnaces.[2] The melting capacity of each furnace ranges from 10 to 12 Mg (11 to 13 tons) per heat. Particulate emissions from each pair of furnaces are controlled by a common fabric filter. The furnaces are equipped with side draft hoods and also with hoods above the pouring spouts and slag doors. All of the hoods for a furnace are connected to a header which discharges to the automatically shaken baghouse. The baghouse fan withdraws an average of 85.9 (dscm/min)/Mg of iron produced (2,745 dscfm/ton). The baghouse is equipped with Dacron filter bags which withstand a maximum temperature of 135°C (275°F) and have an air-to-cloth ratio of 1.9:1. Roof fans and monitors ventilate the furnace and scrap bays and also withdraw small amounts of air from adjacent foundry areas. Sampling at Plant B was performed only at the outlet of the control device. The two furnaces tested (Nos. 3 and 4) were performing at design capacity, and the baghouse was operating normally during the test. The furnaces were on a staggered schedule. The sampling cycle was begun at the beginning of a heat on one furnace and continued for approximately 3 hours. The average heat lasted about 70 minutes, and sampling covered at least two full heats on

---

*mg/dscm = milligrams per dry standard cubic meter.
gr/dscf = grains per dry standard cubic foot.

each furnace. Sampling results are presented in Table C-5. The particulate concentrations (probe and filter) from the three samples were 15.0, 8.8, and 8.6 mg/dscm, averaging 10.8 mg/dscm (0.0066, 0.0038, and 0.0038 gr/dscf, averaging 0.0048 gr/dscf).

Concurrent with the particulate sampling, visible emissions data were obtained for the stack of the baghouse and also the roof monitor vent above the furnaces. The results are presented in Tables C-19 through C-24. The maximum 6-minute average opacity at the baghouse stack was 11.5 percent and was 5 percent or less about 90 percent of the time. At the roof monitor, the maximum 6-minute average opacity was only 2.3 percent.

C.1.1.3 Plant C. Plant C has two furnaces which produce up to 7 Mg (8 tons) of gray iron each per heat.[3] Each arc furnace is controlled by a separate fabric filter, and both furnaces and collectors are retrofits. The furnaces are equipped with roof type hoods and also with hoods above the pouring spout and slag door which are connected to individual takeoff boxes. The exhaust gas flow rate averaged 56.0 (dscm/min)/Mg of iron produced (1,805 dscfm/ton). The Orlon* filter bags withstand a maximum temperature of 107°C (225°F), and the air-to-cloth ratio is 2.8:1. The furnace tested (south furnace) and the fabric filter were operating normally during the tests. Furnace production during each test varied, namely 7, 6, and 4.5 Mg (8, 7, and 5 tons) per heat for each of the three sampling periods. Roof fans and monitors ventilate the furnace and scrap bays, withdrawing small amounts of air from adjacent areas and exhausting directly to the atmosphere.

Particulates, carbon monoxide, hydrocarbons, sulfur, and nitrogen oxides were measured at the discharge of the control device. Each sample was collected during a 1.5-hour period. Sampling periods coincided with the beginning of a furnace heat and were completed prior to the end of the heat. An average furnace heat lasted about 90 minutes. The particulate emissions for the three tests were 45.0, 53.0, and 78.7 mg/dscm, averaging 58.9 mg/dscm (0.0197, 0.0232, and 0.0344 gr/dscf, averaging 0.0257 gr/dscf). These results are presented in Table C-6. Emissions at Plant C are higher than at the other facilities for two probable reasons.

---

*Mention of trade names does not constitute endorsement by EPA.

These are:

1. The collector is manually shaken at irregular intervals and therefore overcleaning is probable. Overcleaning results in a poor filter cake buildup, reduced collection efficiency, and higher emissions.

2. During the period of the testing, carbon raiser was injected into the molten bath using compressed air. When this method of carbon injection is used, only about 60 to 85 percent of the carbon is dissolved in the metal or retained in the slag; the rest escapes the furnace to the baghouse. Because of the very small particle size, only a portion of the carbon particles are collected in the baghouse.

This foundry currently uses the pressure lance method of carbon injection only one percent of the time and would not use it again should a new foundry be built.[7] Since other methods for introducing the carbon into the molten bath exist, are used more frequently than pressure lancing, produce lower emission rates, and are economically viable, the data for Plant C will not be used as a part of the data base.

Visible emissions data were also obtained at Plant C during sampling periods for the baghouse exhaust stack. The results are presented in Tables C-25 through C-30. The maximum 6-minute average opacity at the stack was 30.4 percent, but occasional peaks of up to 100 percent were observed for short periods (several seconds only). At the stack, the opacity (6-minute average) was 5 percent or less about 70 percent of the time. The much higher opacity of the emissions from this plant are consistent with the higher particulate emissions.

C.1.1.4 Plant D. Plant D has one furnace, which produces 5 Mg (6 tons) of gray iron per heat.[4] The arc furnace is surrounded on three sides by two walls and the transformer room so that fumes from charging and upset conditions (gas puffs escaping through the electrode holes or other furnace openings) are directed upward to a ventilation fan located above the furnace. Thus, fugitive emissions from the furnace are emitted to the atmosphere in greater concentrations than at the other foundries tested in this program. In the previous foundries, the furnaces were located in large open bay areas. Consequently, the furnace emissions were subject to cross-drafts and drifted at times sidewards instead of upwards. The furnace at Plant D is retrofitted with a side draft hood and with hoods above the pouring spout and slag door. The discharge rate to the fabric filter averaged 91.5 (dscm/min)/Mg of iron produced (2,910 dscfm/ton). The Dacron filter bags withstand a maximum temperature of 135°C (275°F) and have an air-to-cloth ratio of 2.6:1. The first test was run for only one hour, i.e., covering only one heat. The next two tests each extended over two heats. Each test was started at the beginning of two consecutive heats and continued for one hour during each heat. An average furnace heat lasted about 70 minutes, and the furnace operated at design capacity. Particulate measurements were made at both the inlet and outlet of the collector. The three measurements showed particulate concentrations of 18.1, 2.9, and 6.1 mg/dscm, averaging 9.1 mg/dscm (0.0079, 0.0013, and 0.0027 gr/dscf, averaging 0.0040 gr/dscf) at the baghouse outlet. The results of the tests are in Tables C-7 and C-8.

Concurrent with the particulate testing, visible emissions data were recorded for the baghouse exhaust stack and the roof monitor vent above the furnace. The data are presented in Tables C-31 through C-37. The highest 6-minute average opacity at the stack was only 5.0 percent. The opacity (6-minute average) at the foundry roof vent was 5 percent or less about 93 percent of the time with a maximum 6-minute average of 7.5 percent.

C.1.1.5 Plant E. Plant E operates one electric arc furnace which produces at a rate of 13 Mg (14 tons) per heat or 6 Mg/h (7 tons/h).[5] Particulate emissions from the furnace are controlled by a fabric filter. The furnace is equipped with a side draft hood and with hoods above the pouring spout and slag door. Roof fans and monitors which discharge directly to the atmosphere ventilate the furnace bay area. Emissions were sampled at the baghouse outlet stack. The bags are made of Dacron and withstand a maximum temperature of 135°C (275°F). The air-to-cloth ratio is 3.1:1. Average particulate loadings, as determined by the three samples, were 12.8, 23.3, and 13.5 mg/dscm, averaging 16.5 mg/dscm (0.0056, 0.0102, and 0.0059 gr/dscf, averaging 0.0072 gr/dscf). These data are presented in Table C-9.

The first test was started at the beginning of one heat; the second test was started one hour after the beginning of a second heat, and the third test was started 1.5 hours after the beginning of a third heat. Because of discrepancies in the isokinetic sampling rate, sampling locations, and sample time vs. process conditions, the data may not be representative of results obtainable from tests adhering to the conditions of EPA Reference Method 5.[8] Therefore, the data will be given less weight in the data base.

C.1.1.6 Plant F. Plant F has two electric arc furnaces each with a melting capacity of 14 to 15 Mg/h (15 to 17 tons/h) or 27 to 32 Mg per heat (29 to 35 tons per heat).[6] One baghouse serves the two gray iron EAF's, two induction holding furnaces, and one duplexing arc furnace. Sampling was conducted at the baghouse stack outlet. The EAF's are equipped with side draft hoods, hoods above the pouring and slag doors, and also with a direct furnace evacuation tap. All hoods are connected to a header which leads to the baghouse. The direct furnace evacuation system is only in operation 20 to 25 minutes at the beginning of the melt until the oil from the scrap charge is burned off. (These furnaces melt scrap consisting of 40 percent by weight of borings and turnings which contain up to 10 percent oil.) Roof fans and roof canopy hoods which exhaust directly to the atmosphere ventilate the furnace bay area and adjacent aisles. Sampling was conducted for two hours with a test method similar to EPA's Reference Method 5. As only slight modifications to the EPA method were made, the data have been determined to be suitable for use in the data base.[9,10] In these tests, the sampling period was not selected to coincide with the beginning of a heat cycle on one of the furnaces. Generally, the furnaces are on a staggered schedule. Specific process and operation data are not available.

The highest particulate concentration during these tests was 10.3 mg/dscm (0.0045 gr/dscf). The lowest level measured was 1.6 mg/dscm (0.0007 gr/dscf), while the average of 16 measurements was 3.7 mg/dscm (0.0016 gr/dscf). The available data are summarized in Table C-10.

C.1.2 Other Emissions

Carbon monoxide levels were measured during the four EPA foundry tests, and the data are presented in Tables C-38 through C-41. During all tests, emissions were continuously monitored with a nondispersive infrared analyzer (NDIR). The sampling location was downstream of the furnace at the fan where the temperature is far below 700°C (1290°F), above which pyrophoric conditions exist. Measurements were begun during charging and continued until the tap was completed.

At Plant A, individual carbon monoxide levels ranged from 33 to 275 ppm with an daily average (based on three test days) of 96 ppm. The overall hourly emission rates were generally uniform, the highest differing from the lowest by about 16 percent. The average level, based on three tests, was 0.58 (kg/h)/(Mg/h) [1.16 (lb/h)/(ton/h)] of melting capacity.

At Plant B, individual carbon monoxide levels ranged from 14 to 142 ppm with an daily average (based on three test days) of 73 ppm. The overall hourly emissions vary somewhat, the highest differing from the lowest by about 33 percent. The average level of carbon monoxide, based on three tests, was 0.35 (kg/h)/(Mg/h) of furnace capacity [0.70(lb/h)/(ton/h)].

At Plant C, individual carbon monoxide levels ranged from 10 to 425 ppm with an daily average (based on three test days) of 115 ppm. The overall hourly emissions also vary, the highest differing from the lowest by about 44 percent. The average level of carbon monoxide, based on three tests, was 0.56 (kg/h)/(Mg/h) [1.12 (lb/h)/(ton/h)].

At Plant D, individual carbon monoxide levels ranged from 0 to 435 ppm with an daily average (based on three test days) of 93 ppm. The highest measurement differs from the lowest by about 60 percent. The average level of carbon monoxide, based on three tests, was 0.87 (kg/h)/(Mg/h) [1.74 (lb/h)/(ton/h)].

During these tests, emissions of sulfur dioxide, hydrocarbons, and nitrogen oxides were also measured. Because no control techniques exist for any of these pollutants on electric arc furnaces, these measurements are not discussed further. Detailed data on these readings are reported in Tables C-38 through C-41.

C.2 PARTICULATE EMISSION LEVELS FROM FABRIC FILTERS AT STEEL ELECTRIC ARC FURNACES

Several steel foundries and air pollution control agencies in the United States and abroad were contacted to obtain emission test data. These data are presented in Table C-42 (United States foundries only) and in Figure C-2. The foreign data are presented for information purposes only and are not part of the data base.

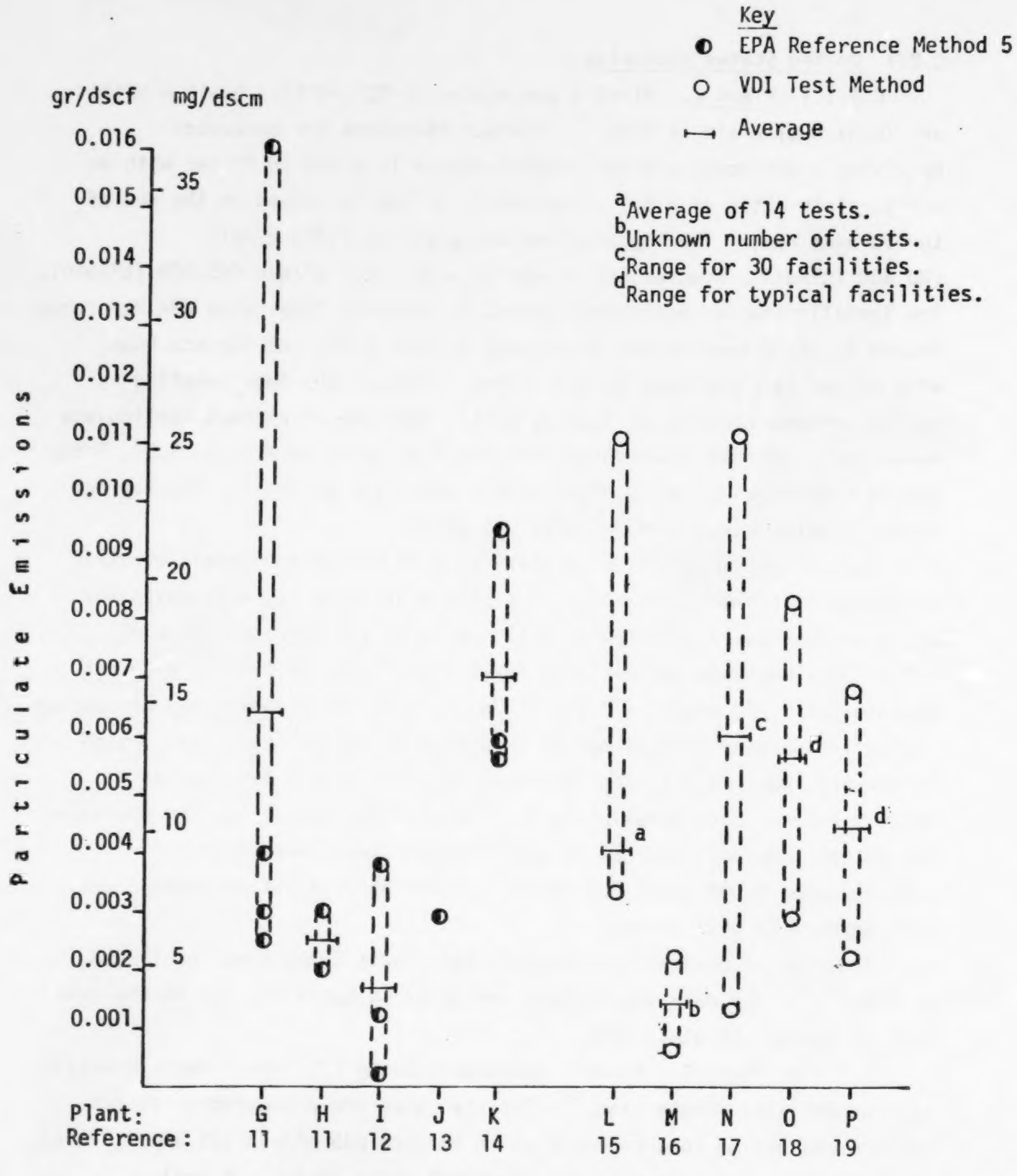


Figure C-2. Summary of source test data for baghouses on EAF's producing steel.

C.2.1 United States Foundries

C.2.1.1 Plant G. Plant G operates a 27-Mg (30-ton) basic electric arc furnace with single slag.[11] Furnace emissions are evacuated by a side draft hood, and the control device is a fabric filter with an air-to-cloth ratio of 2.5:1. The fabric filter is shaken at the end of the furnace heat. The baghouse was designed for 2,275 m^3/min (80,400 ft^3/min); however, it is operated at 1,980 m^3/min (68,800 ft^3/min). The installation was acceptance tested in February 1969 using EPA Reference Method 5. Each test lasted 60 minutes whereas a typical furnace heat with oxygen lancing lasts about 2 hours. Each of the four sampling periods encompassed oxygen lancing (i.e., the time of highest particulate emissions). The outlet loadings for the four tests were 9.15, 5.72, 6.97, and 36.6 mg/dscm (0.004, 0.0025, 0.003, and 0.016 gr/dscf). The average outlet loading was 14.6 mg/dscm (0.064 gr/dscf).

C.2.1.2 Plant H. Plant H operates a 30-Mg (33-ton) basic electric arc furnace with a single slag.[11] A side draft hood collects emissions which are exhausted to a fabric filter with an air-to-cloth ratio of 2.5:1. The baghouse was designed for 2,800 m^3/min (98,000 ft^3/min) but operates at 2,200 m^3/min (77,000 ft^3/min). The installation was acceptance tested in February 1969 using EPA Reference Method 5. Each test lasted 60 minutes, whereas a typical furnace heat with oxygen lancing lasts about 2 hours. Each sampling period included the oxygen lancing operation. The outlet loadings recorded in two different tests were 4.58 and 6.87 mg/dscm (0.002 and 0.003 gr/dscf). The average outlet loading was 5.73 mg/dscm (0.0025 gr/dscf).

A review of partial test reports for plants G and H was performed by EPA.[20,21] The data were determined to be suitable for use in the data base in support of other data.

C.2.1.3 Plant I. Plant I operates a 33-Mg (36.5-ton) basic electric arc furnace with single slag.[12] Furnace gases are evacuated by direct furnace evacuation to a baghouse which handles 835 m^3/min (29,550 ft^3/min). The Dacron bags operate at an air-to-cloth ratio of 2:1. A typical furnace heat with oxygen lancing lasts 3 to 4 hours depending on the availability of electrical energy. The tests were carried out using EPA Reference Method 5. The first test encompassed the backcharging, and the total test time was 80 minutes. The second test was conducted near the middle of a 5-hour heat, and the total time for the second test was also 80 minutes. The third test, of 30 minutes duration, was conducted after backcharging but prior to oxygen lancing. The outlet particulate loadings recorded in the three tests were 0.53, 2.75, and 8.70 mg/dscm (0.0002, 0.0012, and 0.0038 gr/dscf), averaging 3.99 mg/dscm (0.0017 gr/dscf). These data will be given less weight in the data base because the sampling periods did not cover similar segments of each heat sampled.

C.2.1.4 Plant J. Plant J operates one basic arc furnace producing 27 Mg (30 tons) per heat with single slag.[13] Direct furnace evacuation directs emissions to a fabric filter. The installation was acceptance tested in May 1973 using EPA Reference Method 5. The gas volume is 2,900 m^3/min (102,600 ft^3/min); the temperature of the outlet gas stream is 49°C (120°F). The tests were run during two consecutive heats, the first handling 28.3 Mg (31.2 tons) of scrap and additives and the second 28.2 Mg (31 tons). The average outlet concentration measured was 6.63 mg/dscm (0.0029 gr/dscf). The entire test lasted 4 hours; 2 hours were needed to complete each heat.

A review of a partial test report indicated that the data were suitable for use in the data base in support of other data.[21,22]

C.2.1.5 Plant K. Plant K operates two arc furnaces having a total capacity of 5.4 Mg (6 tons).[14] Furnace emissions are evacuated by a modified close capture system to a fabric filter having an air-to-cloth ratio of 2.25:1. The design flow for the baghouse is 1,420 m^3/min (50,000 ft^3/min). The installation was tested in September 1977 using EPA Reference Method 5. Each test lasted 88 minutes whereas a typical heat lasts about 65 minutes, tap to tap. The outlet particulate concentrations were 13.5, 12.8, and 21.7 mg/dscm (0.0059, 0.0056, and 0.0095 gr/dscf). The average outlet was 16.0 mg/dscm (0.0070 gr/dscf) particulate concentration.

C.2.2 Foreign Foundries

The data for Plants L, M, and N originate in the Federal Republic of Germany. The data for Plant O originate in France while those for Plant P originate in Italy. All these data are based on tests conducted with the VDI particulate test method which is not identical to EPA Reference Method 5. Based on previous tests carried out in Germany on municipal incinerators, EPA Reference Method 5 collected 30 percent more dust from the cleaned gas stream than did the German VDI method. The German test results are very similar to those obtained from steel electric arc furnaces in the United States if this correction is applied, as shown in Figure C-2.

Plant L operates a 20 to 22 Mg (22 to 24.2 tons) basic electric arc furnace with single slag.[15] Furnace gases are also evacuated by direct shell evacuation to a fabric filter which treats about 28,000 to 30,000 dscm/h (16,500 to 17,700 dscfm). Emission sampling tests were conducted at both the inlet and the outlet of the baghouse. Outlet particulate loadings ranged between 6 and 20 mg/dscm (0.0026 to 0.0087 gr/dscf), with an average for 14 tests of 7 mg/dscm (0.0031 gr/dscf). The highest loadings were experienced during oxygen lancing. A normal heat for this furnace lasts 2.5 hours.

Plant M has two furnaces, one producing 7 Mg (8 tons) per heat and the other 4 Mg (4.4 tons) per heat.[16] The gas volume for the first furnace is 16,000 dscm/h (9,400 dscfm) and for the second is 12,000 dscm/h (7,100 dscfm). Furnace exhausts are controlled by a single fabric filter. The outlet temperature is 70° to 80°C (160° to 180°F). Inlet and outlet loadings were taken during tests; outlet loadings ranged between 1 and 4 mg/dscm (0.0004 and 0.0017 gr/dscf).

A German company reports that the outlet loadings range between 2 and 20 mg/dscm (0.0009 and 0.0087 gr/dscf) for about 30 fabric filters installed in plants (represented as Plant N) producing steel castings (mostly with direct shell evacuation).[17] Higher emissions were experienced on charges that contained large amounts of swarf.

A French company that has built many control devices for steel electric arc furnaces for general steel production and which has pioneered some of today's techniques in the control of fumes from arc furnaces was also contacted (represented as Plant O).[18] The company reports that emissions on steel arc furnaces, similar in size to those used for steel castings, range between 5 and 15 mg/dscm (0.0022 and 0.0066 gr/dscf) and that there are no visible emissions at the stack of the control devices. The higher loadings occur at older installations.

Emissions from well-controlled (fabric filters) electric arc furnaces in steel foundries in Italy (represented as Plant P) are reported to range between 4 and 12 mg/dscm (0.0017 and 0.0052 gr/dscf).[19]

C.3 VISIBLE EMISSION OBSERVATIONS OF PROCESS EMISSIONS AT STEEL FOUNDRIES

Visible emission observations were performed by EPA personnel at Plants G and I.[23,24] These data are summarized in Table C-2.

Stack opacity (6-minute averages) ranged from 0 to 21.9 percent with 6-minute average readings of 5 percent or less for 91 percent of the time. The maximum 6-minute average opacity during oxygen lancing was 2.7 percent. These observations were not performed at the same time as the particulate tests noted earlier. The opacity of the baghouse exhaust at steel foundries may be lower than at iron foundries because the carbon black added to iron is not completely absorbed by the melt. Five to forty percent of carbon added to iron furnaces escapes in the furnace exhaust gas, and these extremely fine particles may also pass through the baghouse.[25] Carbon black addition is generally not done at steel foundries.

Maximum opacity (6-minute average) reported from roof vents and monitors was 16.7 percent at Plant G and 9.8 percent at Plant I. The maximum value for Plant G was observed during tapping. It is not known what phase of the process operation corresponds to the maximum value at Plant I. Neither facility had charging or tapping emission capture systems. The maximum 6-minute average opacity during oxygen lancing was 6.9 percent at Plant I. No visible emissions were observed during the melt cycle, including oxygen lancing, at the roof vents of Plant G. The 6-minute average opacity from the roof vents at Plant I was 5 percent or less 89 percent of the time. The opacities were highest during tapping because of alloy addition to the ladle. Charging generated substantially fewer visible emissions at the shop roof while backcharging emission levels were between tapping and charging in magnitude for Plant G. Because of the quantity of alloys added to the ladle and the hotter tap temperature, fugitive emissions from steel production are generally somewhat greater in magnitude than those from iron production.[26] The opacity data are detailed in Tables C-43 to C-52.

TABLE C-2. SUMMARY OF VISIBLE EMISSION DATA FOR EAF'S PRODUCING STEEL[a] (6-minute averages)

	Stack		Roof vent	
Plant	Maximum	Percent of time ≦ 10%	Maximum	Percent of time ≦ 10%
G[23]	21.9	93	0.0	100
I[24]	4.0	100	10.0	100

[a] Melting and refining, including oxygen lancing, only.

The high opacity levels shown for Plant G may result from the fact that at this plant the bags are shaken once between heats. Following shaking, a certain time is required for a filter cake to build up and provide efficient filtering. During this time, some emissions might escape and cause a visible plume. Inspection of the bags one week after the visit of the EPA engineers revealed that three to four bags were cracked. This could also result in higher-than-normal visible emissions.

C.4 VISIBLE EMISSION OBSERVATIONS OF EMISSION CAPTURE DEVICES AT STEEL FOUNDRIES

Visible emission observations were made using EPA Reference Methods 9 (indoors) and 22 at a steel foundry that utilizes a tapping pit enclosure for tapping emission control.[27] This facility has two furnaces, one of 22.7-Mg capacity (20 tons) and the other of 9.1-Mg capacity (10 tons). The enclosure system on the 22.7-Mg furnace was not operating properly; therefore, data for that furnace are not presented. A summary of the results of the observations is given in Table C-53.

For this series of observations, emmission readings were made for the period of time encompassing the start of metal flow to the end of metal flow. As tapping on the 9.1-Mg furnace lasted only 2 to 3 minutes, 6-minute average readings could not be made. Except for the first two sets of readings, observations were made approximately 1.8 m (6 ft) above the roof of the pit enclosure. This foundry practices reladling (refurnacing) in which one-third to one-half of the molten metal is poured into the ladle and then returned to the furnace. This operation lasts approximately one minute which is not enough time for EPA Reference Method 9 readings. This facility practices only a limited amount of alloying in the ladle.

For the last three sets of readings, the emissions rose 1.8 m (6 ft) above the roof of the tapping pit enclosure approximately 30 percent of the time and had an average opacity of 15 percent or less.

TABLE C-3. SUMMARY OF PARTICULATE RESULTS FACILITY A (BAGHOUSE INLET)

Run number Date	Units	2 6-19-74	3 6-19-74	4 6-20-74	Average
Test data					
Sampling time	min	180	180	180	
Average total furnace production (2 furnaces)	ton/h	27.6	33.0	28.4	29.7
	Mg/h	25.0	29.9	25.8	26.9
Nominal furnace capacity (2 furnaces)	ton	31.3	32.1	31.6	31.7
	Mg	28.4	29.1	28.7	28.8
Shop effluent					
Flow rate	acfm	95,431	85,721	90,990	90,714
	m^3/min	2,702	2,427	2,577	2,569
	dscfm	72,783	65,176	70,069	69,343
	Nm^3/min	2,061	1,846	1,984	1,964
Flow rate per capacity	dscfm/ton	2,325	2,030	2,215	2,185
	(Nm^3/min)/Mg	72.6	63.4	69.1	68.2
Temperature	°F	188	185	189	187
	°C	87	85	87	86
Water vapor	%, volume	2.5	3.1	1.6	2.4
CO_2, dry	%, volume	0.3	0.3	0.3	0.3
O_2, dry	%, volume	19.5	19.5	20.1	19.7
Particulate emissions					
Probe and filter catch:					
Concentration	gr/acf	0.2132	0.2626	0.2491	0.2416
	mg/m^3	488	601	570	553
	gr/dscf	0.2766	0.3415	0.3201	0.3127
	mg/Nm^3	635	783	734	717
Emission rate	lb/h	172.5	190.7	192.2	185.1
	kg/h	78.2	86.5	87.2	84.0
Emission factor (emission rate per furnace production)	lb/ton	6.25	5.78	6.77	6.23
	kg/Mg	3.13	2.89	3.38	3.12
Total catch:					
Concentration	gr/acf	0.2281	0.2837	0.2529	0.2549
	mg/m^3	522	649	579	583
	gr/dscf	0.2960	0.3690	0.3250	0.3300
	mg/Nm^3	676	845	744	755
Emission rate	lb/h	184	206	195	195
	kg/h	83.5	93.4	88.5	88.5
Emission factor	lb/ton	6.67	6.24	6.87	6.57
	kg/Mg	3.34	3.12	3.43	3.29

TABLE C-4. SUMMARY OF PARTICULATE RESULTS FACILITY A (BAGHOUSE OUTLET)

Run number Date	Units	1 6-18-74	2 6-19-74	3 6-19-74	4 6-20-74	Average (2-4)
Test data						
Sampling time	min	180	180	180	180	
Average total furnace production (2 furnaces)	ton/h	28.6	27.6	33.0	28.4	29.7
	Mg/h	25.9	25.0	29.9	25.8	26.9
Nominal furnace capacity (2 furnaces)	ton	31.9	31.3	32.1	31.6	31.7
	Mg	28.9	28.4	29.1	28.7	28.8
Shop effluent						
Flow rate	acfm	96,674	100,302	98,140	100,111	99,349
	m^3/min	2,738	2,840	2,779	2,835	2,813
	dscfm	79,992	78,432	76,080	76,985	77,465
	Nm^3/min	2,265	2,221	2,154	2,180	2,193
Flow rate per capacity	dscfm/ton	2,510	2,505	2,370	2,435	2,445
	(Nm^3/min)/Mg	78.4	78.2	74.0	76.0	76.1
Temperature	°F	183	177	185	188	182
	°C	84	81	85	87	84
Water vapor	%, volume	2.2	2.7	2.4	2.9	2.7
CO_2, dry	%, volume	0.3	0.3	0.3	0.3	0.3
O_2, dry	%, volume	19.7	19.5	19.5	20.1	19.7
Particulate emissions						
Probe and filter catch:						
Concentration	gr/acf	0.0029	0.0027	0.0022	0.0042	0.0031
	mg/m^3	6.64	6.40	5.03	9.61	7.01
	gr/dscf	0.0038	0.0035	0.0028	0.0054	0.0039
	mg/Nm^3	8.70	8.02	6.46	12.3	8.93
Emission rate	lb/h	2.44	2.35	1.83	3.56	2.59
	kg/h	1.11	1.07	0.83	1.61	1.17
Emission factor (emission rate per furnace production)	lb/ton	0.085	0.085	0.055	0.125	0.087
	kg/Mg	0.043	0.043	0.028	0.062	0.043
Total catch:						
Concentration	gr/acf	0.0056	0.0045	0.0034	0.0056	0.0045
	mg/m^3	12.8	10.3	7.8	12.8	10.3
	gr/dscf	0.0072	0.0057	0.0044	0.0073	0.0058
	mg/Nm^3	16.5	13.1	10.1	16.8	13.3
Emission rate	lb/h	4.62	3.83	2.87	4.83	3.86
	kg/h	2.10	1.74	1.30	2.19	1.75
Emission factor	lb/ton	0.162	0.139	0.087	0.170	0.130
	kg/Mg	0.081	0.070	0.043	0.085	0.065

TABLE C-5. SUMMARY OF PARTICULATE RESULTS FACILITY B (BAGHOUSE OUTLET)

Run number Date	Units	1 7-8-74	2 7-9-74	3 7-9-74	Average
Test data					
Sampling time	min	180	180	180	
Average total furnace production	ton/h	31.2	31.0	33.2	31.8
(2 furnaces)	Mg/h	28.3	28.1	30.1	28.8
Nominal furnace capacity	ton	24.4	24.5	24.3	24.4
(2 furnaces)	Mg	22.1	22.2	22.0	22.1
Shop effluent					
Flow rate	acfm	85,212	86,454	84,818	85,495
	m^3/min	2,413	2,448	2,402	2,421
	dscfm	65,973	69,611	65,508	67,031
	Nm^3/min	1,868	1,971	1,855	1,898
Flow rate per capacity	dscfm/ton	2,705	2,840	2,695	2,745
	(Nm^3/min)/Mg	84.5	88.8	84.3	85.9
Temperature	°F	197	171	195	188
	°C	92	77	91	87
Water vapor	%, volume	3.0	2.8	3.2	3.0
CO_2, dry	%, volume	0.3	0.2	0.2	0.2
O_2, dry	%, volume	19.3	20.0	20.0	19.8
Particulate emissions					
Probe and filter catch:					
Concentration	gr/acf	0.0051	0.0031	0.0029	0.0037
	mg/m^3	11.6	7.2	6.6	8.5
	gr/dscf	0.0066	0.0038	0.0038	0.0048
	mg/Nm^3	15.0	8.8	8.6	10.8
Emission rate	lb/h	3.72	2.26	2.11	2.71
	kg/h	1.69	1.04	0.96	1.23
Emission factor	lb/ton	0.119	0.073	0.064	0.085
(emission rate per furnace production)	kg/Mg	0.060	0.037	0.032	0.043
Total catch:					
Concentration	gr/acf	0.0084	0.0052	0.0039	0.0058
	mg/m^3	19.2	11.9	9.0	13.4
	gr/dscf	0.0109	0.0064	0.0050	0.0074
	mg/Nm^3	24.9	14.6	11.5	17.0
Emission rate	lb/h	6.17	3.81	2.83	4.27
	kg/h	2.80	1.72	1.28	1.93
Emission factor	lb/ton	0.198	0.123	0.085	0.134
	kg/Mg	0.099	0.061	0.043	0.067

TABLE C-6. SUMMARY OF PARTICULATE RESULTS FACILITY C (BAGHOUSE OUTLET)

Run number Date	Units	1 9-18-74	2 9-18-74	3 9-19-74	Average
Test data					
Sampling time	min	120	78	120	
Average total furnace production	ton/h	3.6	3.9	4.1	3.9
	Mg/h	3.3	3.5	3.7	3.5
Nominal furnace capacity	ton	7.2	5.1	8.2	6.8
	Mg	6.5	4.6	7.4	6.2
Shop effluent					
Flow rate	acfm	14,771	15,196	14,987	14,985
	m^3/min	418	430	424	424
	dscfm	12,006	12,317	12,463	12,262
	Nm^3/min	340	349	353	347
Flow rate per capacity	dscfm/ton	1,670	2,415	1,520	1,805
	(Nm^3/min)/Mg	52.3	75.9	47.7	56.0
Temperature	°F	184	186	161	177
	°C	84	86	72	81
Water vapor	%, volume	0.7	0.7	1.0	0.8
CO_2, dry	%, volume	0.7	0.5	0.5	0.6
O_2, dry	%, volume	20.6	20.4	21.0	20.7
Particulate emissions					
Probe and filter catch:					
Concentration	gr/acf	0.0160	0.0188	0.0286	0.0211
	mg/m^3	36.6	43.0	65.4	48.3
	gr/dscf	0.0197	0.0232	0.0344	0.0257
	mg/Nm^3	45.0	53.0	78.7	58.9
Emission rate	lb/h	2.03	2.45	3.67	2.71
	kg/h	0.92	1.11	1.67	1.23
Emission factor (emission rate per furnace production)	lb/ton	0.564	0.628	0.895	0.695
	kg/Mg	0.279	0.317	0.451	0.351

TABLE C-7. SUMMARY OF PARTICULATE RESULTS FACILITY D (BAGHOUSE INLET)

Run number Date	Units	1 10-1-74	2 10-2-74	3 10-3-74	Average
Test data					
Sampling time	min	60	120	120	
Average total furnace production	ton/h	4.6	3.9	4.4	4.3
	Mg/h	4.2	3.5	4.0	3.9
Nominal furnace capacity	ton	6.1	6.1	6.1	6.1
	Mg	5.5	5.5	5.5	5.5
Shop effluent					
Flow rate	acfm	21,783	26,815	22,086	23,561
	m^3/min	617	759	625	667
	dscfm	19,166	23,855	19,387	20,803
	Nm^3/min	543	676	549	589
Flow rate per capacity	dscfm/ton	3,140	3,910	3,180	3,410
	(Nm^3/min)/Mg	98.7	122.9	99.8	107.1
Temperature	°F	125	124	126	125
	°C	52	51	52	52
Water vapor	%, volume	0.8	0.1	0.5	0.5
CO_2, dry	%, volume	0.8	3.9	3.8	2.8
O_2, dry	%, volume	19.7	17.7	20.0	19.1
Particulate emissions					
Probe and filter catch:					
Concentration	gr/acf	0.3630	0.2550	0.4063	0.3414
	mg/m^3	831	584	930	782
	gr/dscf	0.4125	0.2867	0.4629	0.3874
	mg/Nm^3	944	656	1,059	886
Emission rate	lb/h	67.8	58.6	76.9	67.8
	kg/h	30.7	26.6	34.9	30.7
Emission factor	lb/ton	14.7	15.0	17.5	15.8
(emission rate per furnace production)	kg/Mg	7.3	7.6	8.7	7.9
Total catch:					
Concentration	gr/acf	0.3750	0.2613	0.4192	0.3518
	mg/m^3	858	598	959	805
	gr/dscf	0.4262	0.2937	0.4776	0.3992
	mg/Nm^3	975	672	1,093	913
Emission rate	lb/h	70.0	60.0	79.4	69.8
	kg/h	31.8	27.2	36.0	31.7
Emission factor	lb/ton	15.2	15.4	18.0	16.2
	kg/Mg	7.6	7.8	9.0	8.1

TABLE C-8. SUMMARY OF PARTICULATE RESULTS FACILITY D (BAGHOUSE OUTLET)

Run number Date	Units	1 10-1-74	2 10-2-74	3 10-3-74	Average
Test data					
Sampling time	min	60	120	120	
Average total furnace production	ton/h	4.6	3.9	4.4	4.3
	Mg/h	4.2	3.5	4.0	3.9
Nominal furnace capacity	ton	6.1	6.1	6.1	6.1
	Mg	5.5	5.5	5.5	5.5
Shop effluent					
Flow rate	acfm	16,790	21,758	20,486	19,678
	m^3/min	475	616	580	557
	dscfm	15,185	20,037	18,061	17,761
	Nm^3/min	430	567	511	503
Flow rate per capacity	dscfm/ton	2,490	3,285	2,960	2,910
	(Nm^3/min)/Mg	78.2	103.1	92.9	91.5
Temperature	°F	112	107	125	115
	°C	45	42	52	46
Water vapor	%, volume	0.8	0.0	0.2	0.3
CO_2, dry	%, volume	0.8	3.9	3.8	2.8
O_2, dry	%, volume	19.7	17.7	20.0	19.1
Particulate emissions					
Probe and filter catch:					
Concentration	gr/acf	0.0072	0.0012	0.0024	0.0036
	mg/m^3	16.40	2.67	5.41	8.16
	gr/dscf	0.0079	0.0013	0.0027	0.0040
	mg/Nm^3	18.13	2.90	6.14	9.06
Emission rate	lb/h	1.03	0.22	0.42	0.56
	kg/h	0.468	0.099	0.188	0.252
Emission factor (emission rate per furnace production)	lb/ton	0.224	0.056	0.095	0.130
	kg/Mg	0.111	0.028	0.047	0.065
Total catch:					
Concentration	gr/acf	0.0213	0.0029	0.0044	0.0095
	mg/m^3	48.70	6.73	10.13	21.85
	gr/dscf	0.0235	0.0032	0.0050	0.0106
	mg/Nm^3	53.85	7.31	11.49	24.22
Emission rate	lb/h	3.06	0.55	0.78	1.46
	kg/h	1.389	0.249	0.353	0.664
Emission factor	lb/ton	0.665	0.141	0.177	0.340
	kg/Mg	0.331	0.071	0.088	0.170

TABLE C-9. SUMMARY OF PARTICULATE RESULTS
FACILITY E (BAGHOUSE OUTLET)

Run number Date	Units	1 5-6-74	2 9-7-74	3 9-7-74	Average
Test data					
Sampling time	min	60	60	60	
Nominal furnace capacity	ton	15.0	15.0	15.0	15.0
	Mg	13.6	13.6	13.6	13.6
Shop effluent					
Flow rate	dscfm	46,118	39,857	40,642	42,206
	Nm^3/min	1,306	1,129	1,151	1,195
Temperature	°F	106	126	128	120
	°C	41	52	53	49
Water vapor	%, volume	0.1	0.5	0.5	0.3
CO_2, dry	%, volume	0	0	0	0
O_2, dry	%, volume	20.7	20.6	20.5	20.6
Particulate emissions					
Probe and filter catch:					
Concentration	gr/dscf	0.0056	0.0102	0.0059	0.0072
	mg/Nm^3	12.8	23.3	13.5	16.5
Emission rate	lb/h	2.06	3.29	1.93	2.43
	kg/h	0.934	1.49	0.875	1.10

TABLE C-10. SUMMARY OF PARTICULATE RESULTS FACILITY F (BAGHOUSE OUTLET)

	Units	Range	Average[a]
Shop effluent			
Flow rate	ft^3/min		2,280
	m^3/min		65
Temperature	°F	95 -180	137.5
	°C	35 - 82	59
Water vapor	%, volume	1 - 2	1.5
CO_2, dry	%, volume		Negligible
O_2, dry	%, volume		21
Particulate emissions			
Probe and filter catch			
Concentration	gr/dscf	0.007 - 0.0045	0.0016
	mg/Nm^3	1.6 - 10.3	3.7
Emission rate	lb/h	1.04 - 6.77	2.43
	kg/h	0.47 - 3.07	1.10

[a] Sixteen tests total.

Table C-11

FACILITY: A

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 18, 1974
Type of Discharge: Particulates Height of Point of Discharge: 40 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 100 ft. Duration: 4 hrs., 15 min.
Direction of Observer from Discharge Point: North
Descript. of Background: Black Bldg. Wind Direction: North Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: 10-15 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	10:45	10:50	0	0	21	12:44	12:50	0	0
2	10:50	10:56	0	0	22	12:50	12:56	0	0
3	10:56	11:02	0	0	23	12:56	1:02	5	0.2
4	11:02	11:08	0	0	24	1:02	1:08	120	5.0
5	11:08	11:14	0	0	25	1:08	1:14	165	6.9
6	11:14	11:20	50	2.1	26	1:14	1:20	230	9.6
7	11:20	11:26	130	5.4	27	1:20	1:26	195	8.1
8	11:26	11:32	120	5.0	28	1:26	1:32	25	1.0
9	11:32	11:38	40	1.7	29	1:32	1:38	40	1.7
10	11:38	11:44	10	0.4	30	1:38	1:44	5	0.2
11	11:44	11:50	5	0.2	31	1:44	1:50	5	0.2
12	11:50	11:56	0	0	32	1:50	1:56	5	0.2
13	11:56	12:02	0	0	33	1:56	2:02	50	2.1
14	12:02	12:08	65	2.7	34	2:02	2:08	90	3.8
15	12:08	12:14	120	5.0	35	2:08	2:14	0	0
16	12:14	12:20	5	0.2	36	2:14	2:20	0	0
17	12:20	12:26	80	3.3	37	2:20	2:26	50	2.1
18	12:26	12:32	45	1.9	38	2:26	2:32	125	5.2
19	12:32	12:38	120	5.0	39	2:32	2:38	115	4.8
20	12:38	12:44	5	0.2	40	2:38	2:44	0	0

Sketch showing how opacity varied with time:

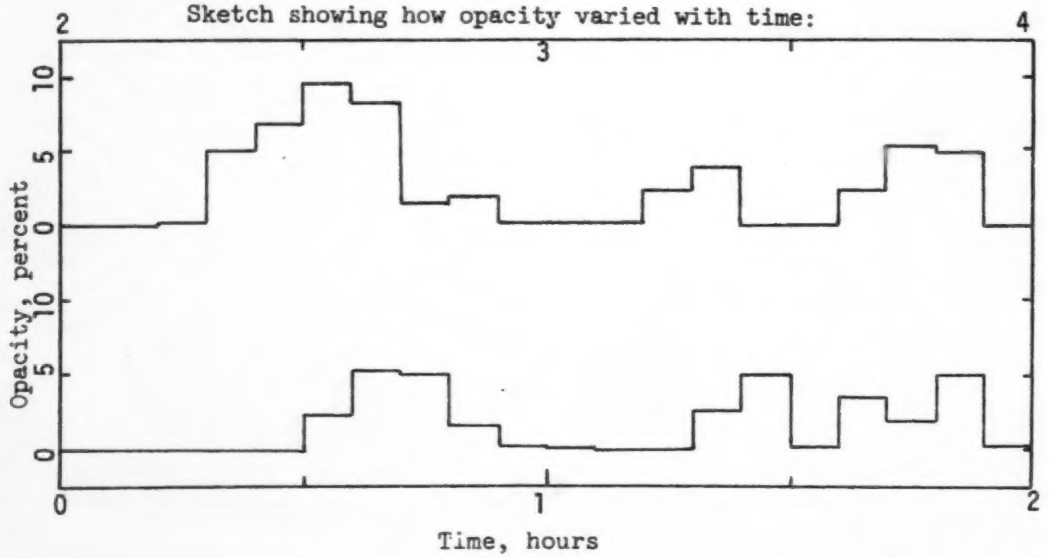


Table C-11 (concluded)

FACILITY: A
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry
Date: June 18, 1974
Type of Discharge: Particulates
Height of Point of Discharge: 40 ft.
Location of Discharge: Stack
Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 100 ft.
Duration: 4 hrs., 15 min.
Direction of Observer from Discharge Point: North
Descript. of Background: Black Bldg.
Wind Direction: North
Color of Plume: Brown
Descript. of Sky: Clear
Wind Velocity: 10-15 mph
Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
41	2:44	2:50	0	0					
42	2:50	2:56	20	0.8					
43	2:56	3:02	0	0					

Sketch showing how opacity varied with time:

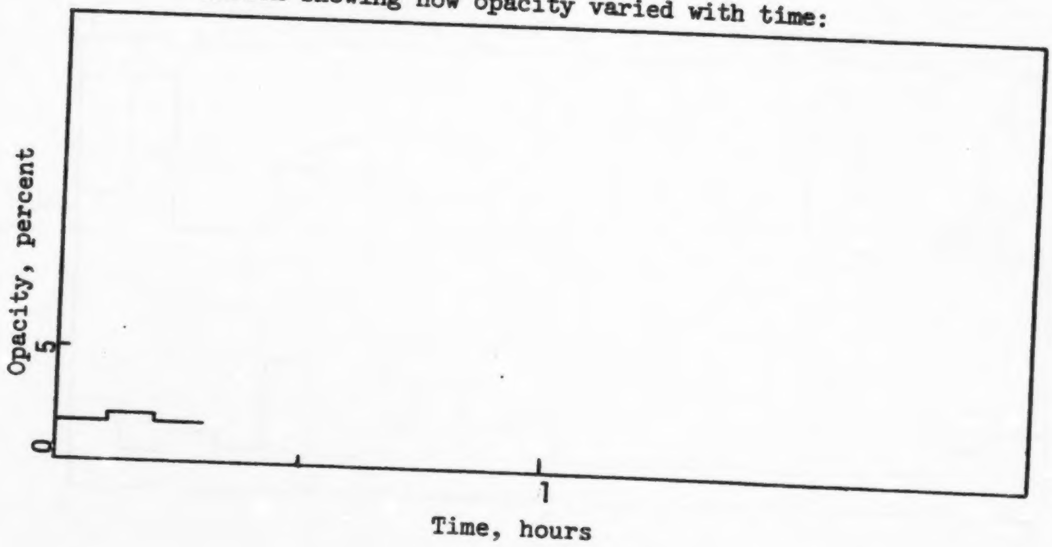


Table C-12

FACILITY: A
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 18, 1974
Type of Discharge: Particulates Height of Point of Discharge: 3 Ft
Location of Discharge: Roof Vents Height of Observation Point: 60 Ft
Distance from Observer to Discharge Point: 24 Ft Duration: 4 Hrs, 10 Min
Direction of Observer from Discharge Point: East of Roof Fan
Descript. of Background: Sky Wind Direction: North Color of Plume: Brown
Descript. of Sky: Sunny Blue Sky Wind Velocity: 10-15 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	10:50	10:56	75	3.1	21	12:50	12:56	0	0
2	10:56	11:02	35	1.5	22	12:56	1:02	45	1.9
3	11:02	11:08	5	0.2	23	1:02	1:08	5	0.2
4	11:08	11:14	0	0	24	1:08	1:14	0	0
5	11:14	11:20	0	0	25	1:14	1:20	250	10.4
6	11:20	11:26	0	0	26	1:20	1:26	30	1.2
7	11:26	11:32	10	0.4	27	1:26	1:32	45	1.9
8	11:32	11:38	0	0	28	1:32	1:38	0	0
9	11:38	11:44	0	0	29	1:38	1:44	195	8.1
10	11:44	11:50	0	0	30	1:44	1:50	25	1.0
11	11:50	11:56	90	3.8	31	1:50	1:56	0	0
12	11:56	12:02	55	2.3	32	1:56	2:02	0	0
13	12:02	12:08	115	4.8	33	2:02	2:08	0	0
14	12:08	12:14	55	2.3	34	2:08	2:14	90	3.8
15	12:14	12:20	0	0	35	2:14	2:20	145	6.0
16	12:20	12:26	150	6.2	36	2:20	2:26	110	4.6
17	12:26	12:32	10	0.4	37	2:26	2:32	0	0
18	12:32	12:38	30	1.2	38	2:32	2:38	0	0
19	12:38	12:44	0	0	39	2:38	2:44	245	10.2
20	12:44	12:50	95	4.0	40	2:44	2:50	75	3.1
					41	2:50	2:56	35	1.5
					42	2:56	3:00	0	0

Sketch showing how opacity varied with time:

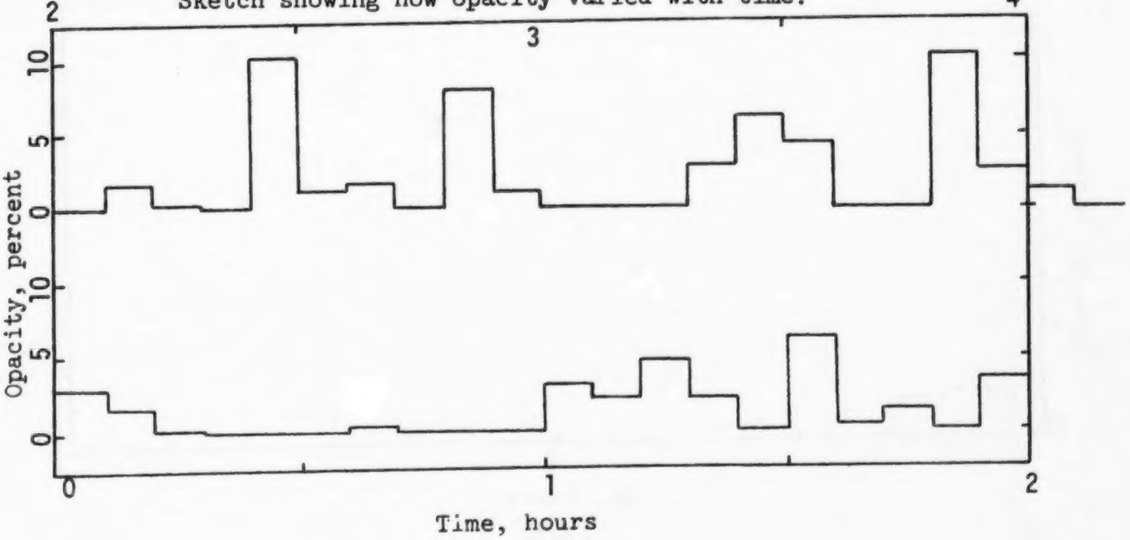


Table C-13

FACILITY: A
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 19, 1974
Type of Discharge: Particulates Height of Point of Discharge: 40 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 100 ft. Duration: 3 hrs., 21 min.
Direction of Observer from Discharge Point: North
Descript. of Background: Dark Gray Side of Bldg. Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: Not Recorded Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	10:00	10:06	0	0	21	12:00	12:06	115	4.8
2	10:06	10:12	5	0.2	22	12:06	12:12	125	5.2
3	10:12	10:18	0	0	23	12:12	12:18	125	5.2
4	10:18	10:24	10	0.4	24	12:18	12:24	65	2.7
5	10:24	10:30	80	3.3	25	12:24	12:30	95	4.0
6	10:30	10:36	90	3.7	26	12:30	12:36	35	1.5
7	10:36	10:42	45	1.9	27	12:36	12:42	10	0.4
8	10:42	10:48	50	2.1	28	12:42	12:48	0	0
9	10:48	10:54	0	0	29	12:48	12:54	5	0.2
10	10:54	11:00	80	3.3	30	12:54	1:00	5	0.2
11	11:00	11:06	75	3.1	31	1:00	1:06	5	0.2
12	11:06	11:12	85	3.5	32	1:06	1:12	5	0.2
13	11:12	11:18	15	0.6	33	1:12	1:18	0	0
14	11:18	11:24	40	1.7	34	1:18	1:21	5	0.2
15	11:24	11:30	45	1.9	35				
16	11:30	11:36	0	0	36				
17	11:36	11:42	10	0.4	37				
18	11:42	11:48	45	1.9	38				
19	11:48	11:54	120	5.0	39				
20	11:54	12:00	55	2.3	40				

Sketch showing how opacity varied with time:

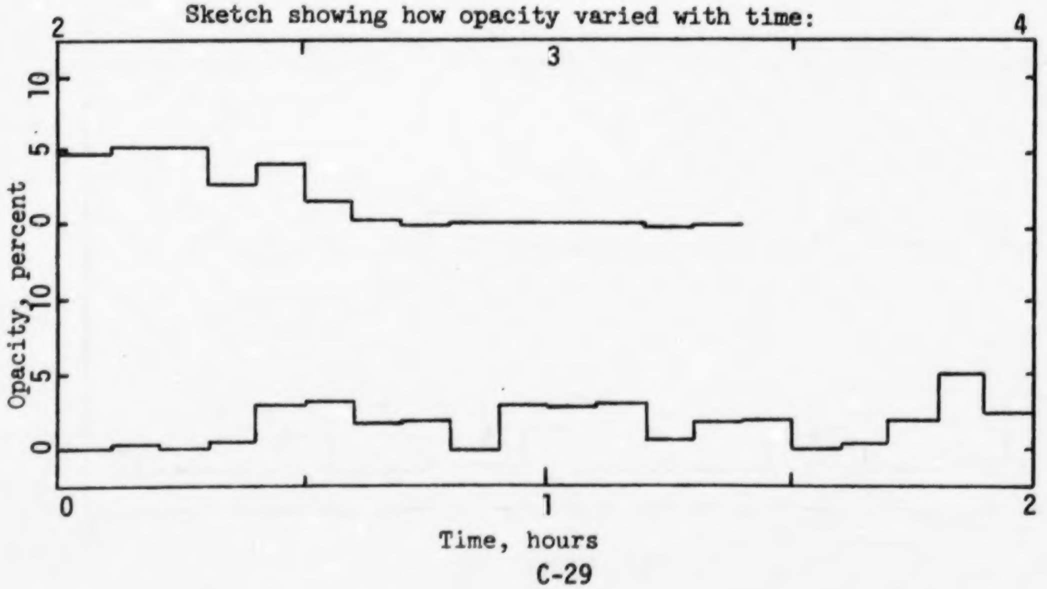


Table C-14

FACILITY: A

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 19, 1974
Type of Discharge: Roof Vent Height of Point of Discharge: 3 ft.
Location of Discharge: Over Furnace No.2 Height of Observation Point: 60 ft.
Distance from Observer to Discharge Point: 24 ft. Duration: 3 hrs., 22 min.
Direction of Observer from Discharge Point: Sun in the Back of Observer
Descript. of Background: Sky Wind Direction: Not Recorded Color of Plume: Brown
Descript. of Sky: Cloudy, Bright Sun Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	10:00	10:06	120	5.0	21	12:00	12:06	0	0
2	10:06	10:12	20	0.8	22	12:06	12:12	0	0
3	10:12	10:18	0	0	23	12:12	12:18	0	0
4	10:18	10:24	0	0	24	12:18	12:24	20	0.8
5	10:24	10:30	40	1.7	25	12:24	12:30	50	2.1
6	10:30	10:36	60	2.5	26	12:30	12:36	0	0
7	10:36	10:42	0	0	27	12:36	12:42	0	0
8	10:42	10:48	0	0	28	12:42	12:48	0	0
9	10:48	10:54	0	0	29	12:48	12:54	0	0
10	10:54	11:00	0	0	30	12:54	1:00	0	0
11	11:00	11:06	65	2.7	31	1:00	1:06	0	0
12	11:06	11:12	10	0.4	32	1:06	1:12	0	0
13	11:12	11:18	20	0.8	33	1:12	1:18	55	2.3
14	11:18	11:24	0	0	34	1:18	1:22	0	0
15	11:24	11:30	0	0	35				
16	11:30	11:36	60	2.5	36				
17	11:36	11:42	0	0	37				
18	11:42	11:48	0	0	38				
19	11:48	11:54	0	0	39				
20	11:54	12:00	35	1.5	40				

Sketch showing how opacity varied with time:

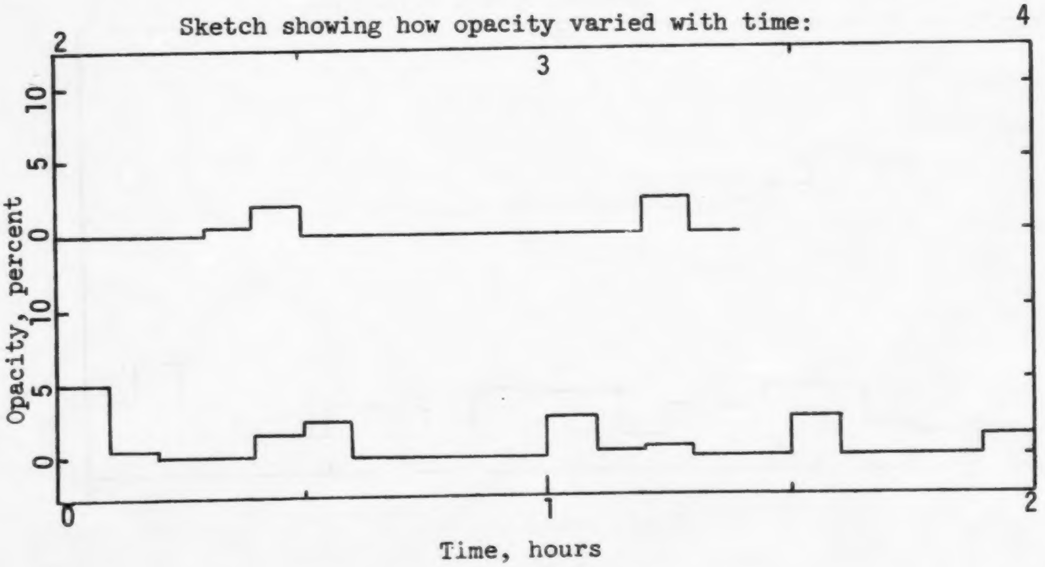


Table C-15

FACILITY: A
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 19, 1974
Type of Discharge: Particulates Height of Point of Discharge: 40 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 100 ft. Duration: 4 hrs.
Direction of Observer from Discharge Point: North
Descript. of Background: Dark Gray Side of Bldg. Wind Direction: Not Rec. Color of Plume: Brown
Descript. of Sky: Cloudy & Sunny (after 6:30 p.m.) Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	4:04	4:10	0	0	21	6:04	6:10	60	2.5
2	4:10	4:16	5	0.2	22	6:10	6:16	15	0.6
3	4:16	4:22	15	0.6	23	6:16	6:22	25	1.0
4	4:22	4:28	30	1.2	24	6:22	6:28	90	3.8
5	4:28	4:34	0	0	25	6:28	6:34	60	2.5
6	4:34	4:40	30	1.2	26	6:34	6:40	85	3.5
7	4:40	4:46	90	3.8	27	6:40	6:46	0	0
8	4:46	4:52	130	5.4	28	6:46	6:52	35	1.5
9	4:52	3:58	120	5.0	29	6:52	6:58	0	0
10	4:58	5:04	120	5.0	30	6:58	7:04	65	2.7
11	5:04	5:10	80	3.3	31	7:04	7:10	125	5.2
12	5:10	5:16	15	0.6	32	7:10	7:16	125	5.2
13	5:16	5:22	5	0.2	33	7:16	7:22	110	4.6
14	5:22	5:28	5	0.2	34	7:22	7:28	5	0.2
15	5:28	5:34	5	0.2	35	7:28	7:34	0	0
16	5:34	5:40	10	0.4	36	7:34	7:40	5	0.2
17	5:40	5:46	75	3.1	37	7:40	7:46	75	3.1
18	5:46	5:52	120	5.0	38	7:46	7:52	75	3.1
19	5:52	5:58	135	5.6	39	7:52	7:58	5	0.2
20	5:58	6:04	125	5.2	40	7:58	8:04	0	0

Sketch showing how opacity varied with time:

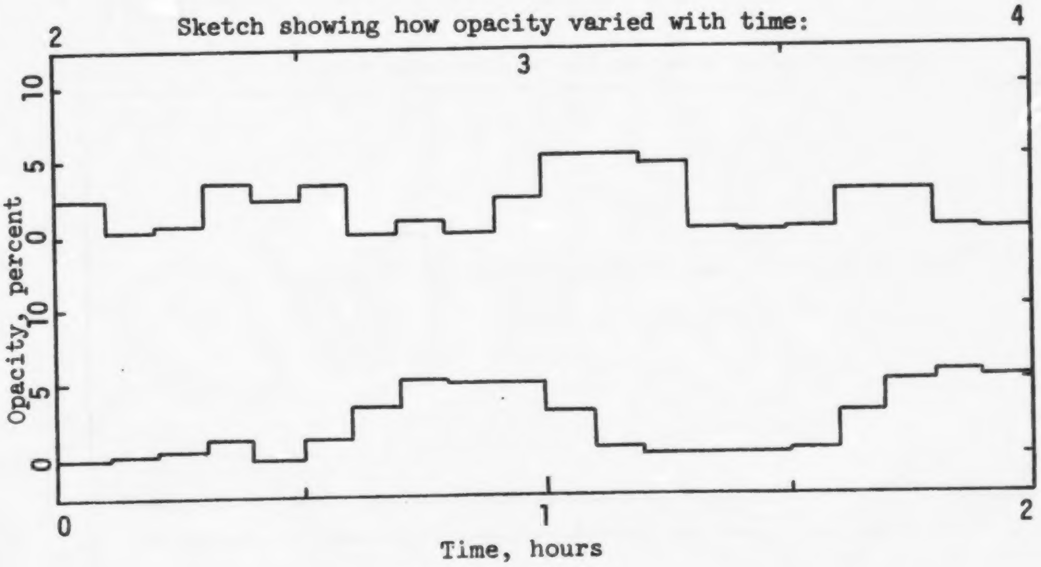


Table C-16

FACILITY: A

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 19, 1974

Type of Discharge: Roof Vent Height of Point of Discharge: 3 ft.

Location of Discharge: Over Furnace No. 2 Height of Observation Point: 60 ft.

Distance from Observer to Discharge Point: 24 ft. Duration: 4 hrs.

Direction of Observer from Discharge Point: East of Roof Fan

Descript. of Background: Sky Wind Direction: Not Rec. Color of Plume: Brown

Descript. of Sky: Cloudy, Rainy to Partly Cloudy Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	4:04	4:10	0	0	21	6:04	6:10	0	0
2	4:10	4:16	0	0	22	6:10	6:16	35	1.5
3	4:16	4:22	0	0	23	6:16	6:22	0	0
4	4:22	4:28	20	0.8	24	6:22	6:28	0	0
5	4:28	4:34	5	0.2	25	6:28	6:34	0	0
6	4:34	4:40	0	0	26	6:34	6:40	0	0
7	4:40	4:46	0	0	27	6:40	6:46	0	0
8	4:46	4:52	0	0	28	6:46	6:52	0	0
9	4:52	4:58	0	0	29	6:52	6:58	0	0
10	4:58	5:04	0	0	30	6:58	7:04	0	0
11	5:04	5:10	0	0	31	7:04	7:10	0	0
12	5:10	5:16	0	0	32	7:10	7:16	0	0
13	5:16	5:22	0	0	33	7:16	7:22	0	0
14	5:22	5:28	0	0	34	7:22	7:28	65	2.7
15	5:28	5:34	0	0	35	7:28	7:34	0	0
16	5:34	5:40	0	0	36	7:34	7:40	0	0
17	5:40	5:46	0	0	37	7:40	7:46	0	0
18	5:46	5:52	0	0	38	7:46	7:52	0	0
19	5:52	5:58	0	0	39	7:52	7:58	0	0
20	5:58	6:04	0	0	40	7:58	8:04	0	0

Sketch showing how opacity varied with time:

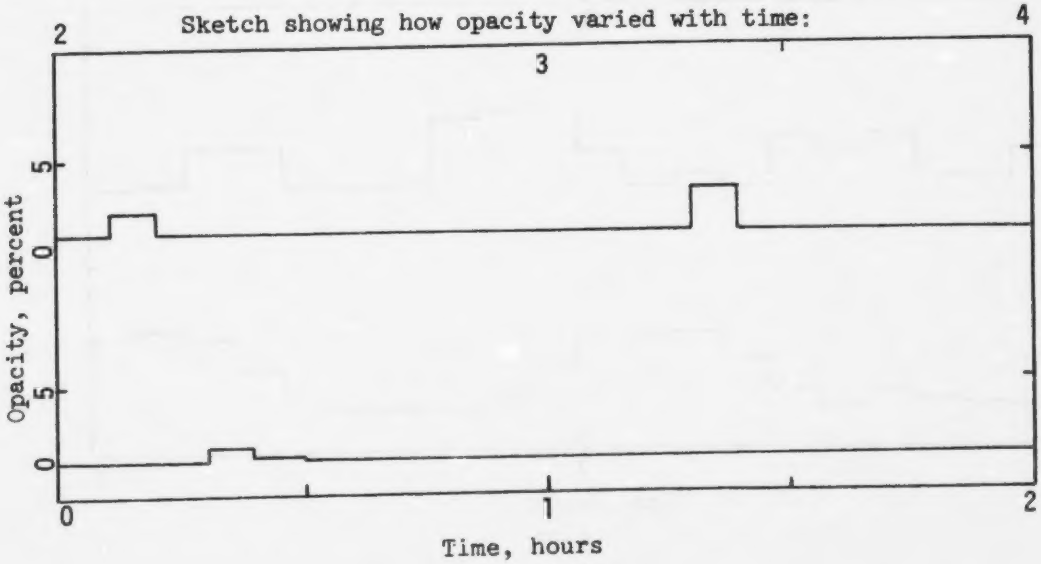


Table C-17

FACILITY: A
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 20, 1974
Type of Discharge: Particulates Height of Point of Discharge: 80 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 40 ft. 100 ft., above observer Duration: 3 hrs., 16 min.
Direction of Observer from Discharge Point: North
Descript. of Background: Dark Gray Side of Bldg. Wind Direction: Not Rec Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: 15 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	9:20	9:26	0	0	21	11:20	11:26	120	5.0
2	9:26	9:32	0	0	22	11:26	11:32	125	5.1
3	9:32	9:38	0	0	23	11:32	11:38	50	2.1
4	9:38	9:44	0	0	24	11:38	11:44	60	2.5
5	9:44	9:50	0	0	25	11:44	11:50	150	6.2
6	9:50	9:56	15	0.6	26	11:50	11:56	55	2.3
7	9:56	10:02	0	0	27	11:56	12:02	30	1.3
8	10:02	10:08	0	0	28	12:02	12:08	5	0.2
9	10:08	10:14	0	0	29	12:08	12:14	0	0
10	10:14	10:20	0	0	30	12:14	12:20	0	0
11	10:20	10:26	0	0	31	12:20	12:26	0	0
12	10:26	10:32	0	0	32	12:26	12:32	0	0
13	10:32	10:38	0	0	33	12:32	12:36	0	0
14	10:38	10:44	0	0	34				
15	10:44	10:50	0	0	35				
16	10:50	10:56	0	0	36				
17	10:56	11:02	0	0	37				
18	11:02	11:08	0	0	38				
19	11:08	11:14	0	0	39				
20	11:14	11:20	40	1.7	40				

Sketch showing how opacity varied with time:

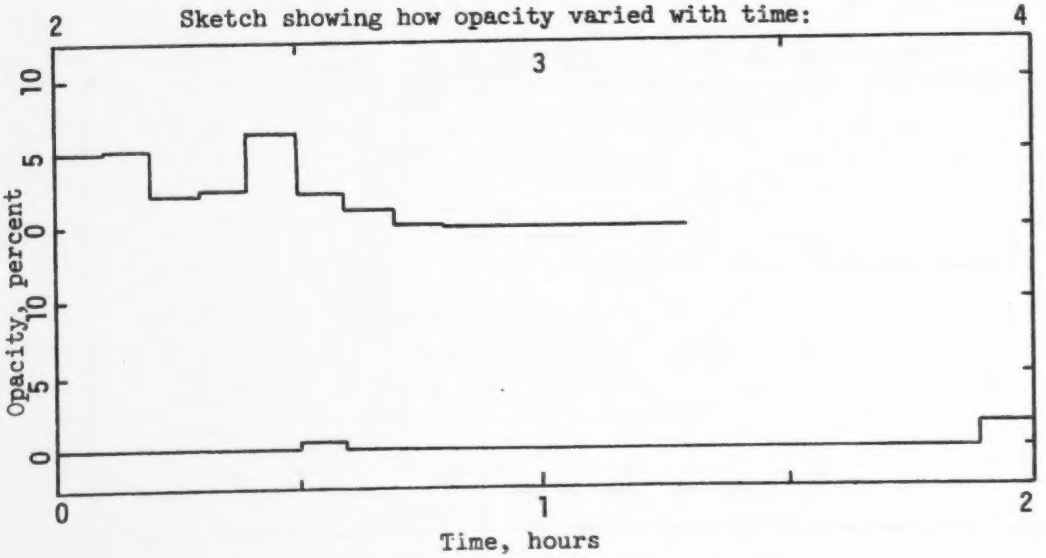


Table C-18

FACILITY: A

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: June 20, 1974
Type of Discharge: Roof Vent Height of Point of Discharge: 3 ft.
Location of Discharge: Over Furnace No.2 Height of Observation Point: 60 ft.
Distance from Observer to Discharge Point: 24 ft. Duration: 3 hrs., 18 min.
Direction of Observer from Discharge Point: East of the Vent
Descript. of Background: Sky Wind Direction: Not Rec Color of Plume: Brown
Descript. of Sky: Sunny with Haze Wind Velocity: 15 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	9:20	9:26	5	0.2	21	11:20	11:26	80	3.3
2	9:26	9:32	0	0	22	11:26	11:32	0	0
3	9:32	9:38	0	0	23	11:32	11:38	0	0
4	9:38	9:44	0	0	24	11:38	11:44	0	0
5	9:44	9:50	10	0.4	25	11:44	11:50	5	0.2
6	9:50	9:56	70	2.9	26	11:50	11:56	60	2.5
7	9:56	10:02	0	0	27	11:56	12:02	0	0
8	10:02	10:08	0	0	28	12:02	12:08	20	0.8
9	10:08	10:14	115	4.8	29	12:08	12:14	0	0
10	10:14	10:20	0	0	30	12:14	12:20	0	0
11	10:20	10:26	0	0	31	12:20	12:26	55	2.3
12	10:26	10:32	0	0	32	12:26	12:32	5	0.2
13	10:32	10:38	30	1.2	33	12:32	12:38	100	4.2
14	10:38	10:44	0	0	34				
15	10:44	10:50	0	0	35				
16	10:50	10:56	35	1.5	36				
17	10:56	11:02	10	0.4	37				
18	11:02	11:08	30	1.2	38				
19	11:08	11:14	0	0	39				
20	11:14	11:20	20	0.8	40				

Sketch showing how opacity varied with time:

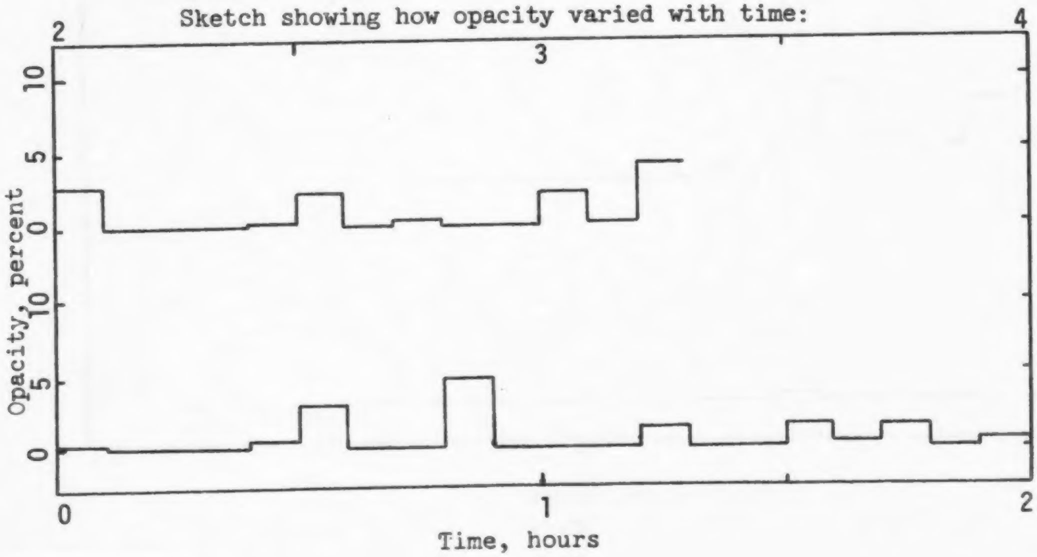


Table C-19

FACILITY: B

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 8, 1974

Type of Discharge: Particulates Height of Point of Discharge: 50 ft.

Location of Discharge: Stack Height of Observation Point: Ground Level

Distance from Observer to Discharge Point: 125 ft. Duration: 3 hrs., 48 min.

Direction of Observer from Discharge Point: South-East

Descript. of Background: Gray Bldgs. & Equipment Wind Direction: Calm Color of Plume: Brown

Descript. of Sky: Sunny, Scat. Clds., Blue Sky, Humid, 95°F Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1:20	1:26	0	0	21	3:20	3:26	50	2.1
2	1:26	1:32	0	0	22	3:26	3:32	25	1.0
3	1:32	1:38	0	0	23	3:32	3:38	35	1.5
4	1:38	1:44	0	0	24	3:38	3:44	0	0
5	1:44	1:50	0	0	25	3:44	3:50	30	1.2
6	1:50	1:56	55	2.3	26	3:50	3:56	10	0.4
7	1:56	2:02	0	0	27	3:56	4:02	0	0
8	2:02	2:08	10	0.4	28	4:02	4:08	0	0
9	2:08	2:14	50	2.1	29	4:08	4:14	25	1.0
10	2:14	2:20	40	1.7	30	4:14	4:20	115	4.8
11	2:20	2:26	70	2.9	31	4:20	4:26	130	5.4
12	2:26	2:32	25	1.0	32	4:26	4:32	50	2.1
13	2:32	2:38	0	0	33	4:32	4:38	55	2.3
14	2:38	2:44	0	0	34	4:38	4:44	65	2.7
15	2:44	2:50	0	0	35	4:44	4:50	145	6.1
16	2:50	2:56	0	0	36	4:50	4:56	40	1.7
17	2:56	3:02	0	0	37	4:56	5:02	0	0
18	3:02	3:08	0	0	38	5:02	5:08	0	0
19	3:08	3:14	0	0	39	5:08	5:10	15	2.5
20	3:14	3:20	0	0	40				

Sketch showing how opacity varied with time:

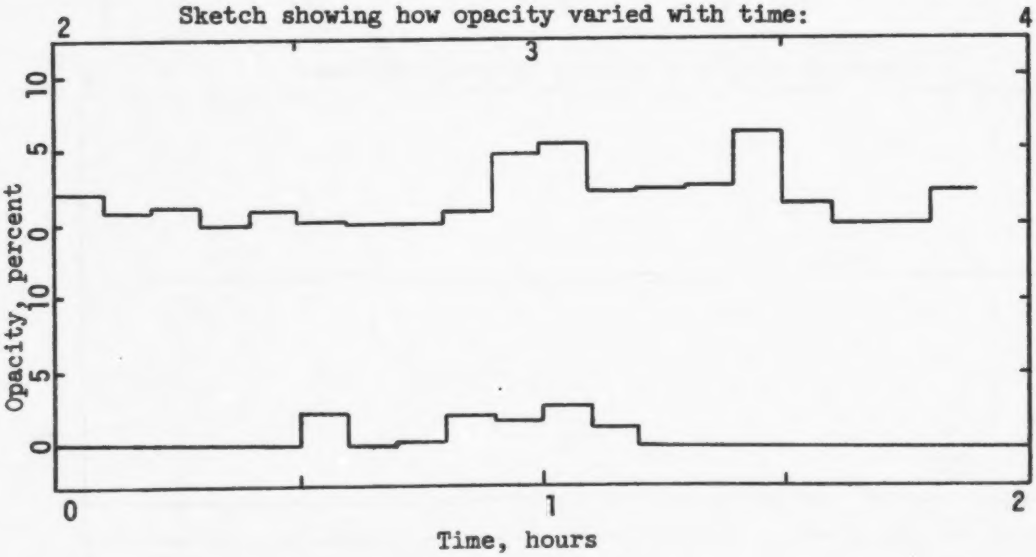


Table C-20

FACILITY: B

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 8, 1974
Type of Discharge: Particulates Height of Point of Discharge: 3 ft. Above Roof
Location of Discharge: Roof Vent Height of Observation Point: At Vent Level
Distance from Observer to Discharge Point: 30 ft. Duration: 3 hrs., 50 min.
Direction of Observer from Discharge Point: 30 ft. South of Discharge Point
Descript. of Background: Sky Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Scattered Clouds Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1:20	1:26	0	0	21	3:20	3:26	0	0
2	1:26	1:32	0	0	22	3:26	3:32	0	0
3	1:32	1:38	0	0	23	3:32	3:38	0	0
4	1:38	1:44	0	0	24	3:38	3:44	10	0.4
5	1:44	1:50	25	1.0	25	3:44	3:50	30	1.2
6	1:50	1:56	0	0	26	3:50	3:56	0	0
7	1:56	2:02	0	0	27	3:56	4:02	0	0
8	2:02	2:08	0	0	28	4:02	4:08	0	0
9	2:08	2:14	0	0	29	4:08	4:14	5	0.2
10	2:14	2:20	0	0	30	4:14	4:20	0	0
11	2:20	2:26	0	0	31	4:20	4:26	0	0
12	2:26	2:32	10	0.4	32	4:26	4:32	0	0
13	2:32	2:38	0	0	33	4:32	4:38	0	0
14	2:38	2:44	0	0	34	4:38	4:44	0	0
15	2:44	2:50	0	0	35	4:44	4:50	15	0.6
16	2:50	2:56	0	0	36	4:50	4:56	0	0
17	2:56	3:02	0	0	37	4:56	5:02	0	0
18	3:02	3:08	0	0	38	5:02	5:08	0	0
19	3:08	3:14	0	0	39	5:08	5:10	0	0
20	3:14	3:20	0	0	40				

Sketch showing how opacity varied with time:

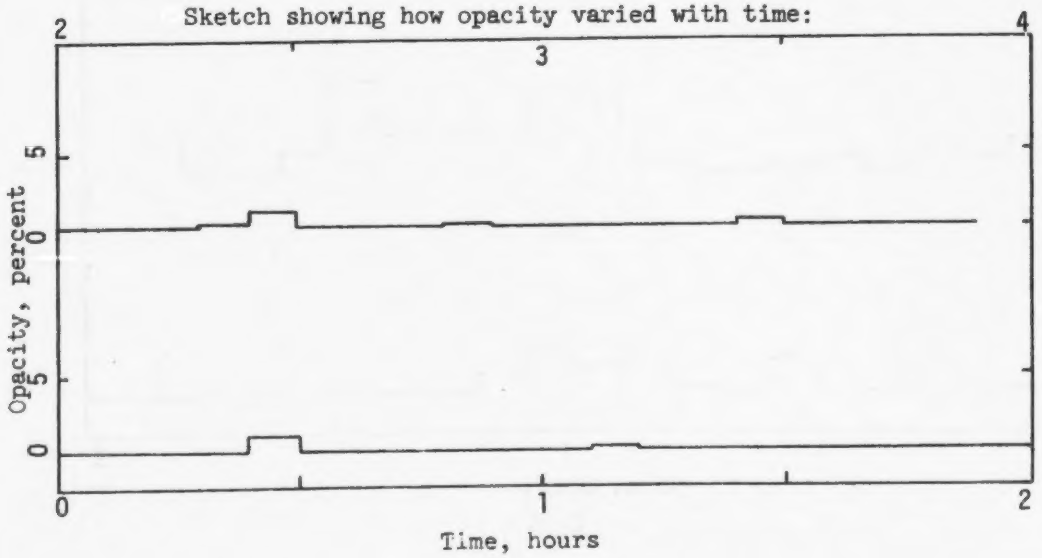


Table C-21

FACILITY: B

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 9, 1974
Type of Discharge: Particulates Height of Point of Discharge: 50 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 125 ft. Duration: 3 hrs., 42 min.
Direction of Observer from Discharge Point: South-East
Descript. of Background: Gray Bldgs. & Equipment Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	7:55	8:01	25	1.0	21	9:55	10:01	25	1.0
2	8:01	8:07	15	0.6	22	10:01	10:07	10	0.4
3	8:07	8:13	30	1.2	23	10:07	10:13	10	0.4
4	8:13	8:19	30	1.2	24	10:13	10:19	0	0
5	8:19	8:25	55	2.3	25	10:19	10:25	0	0
6	8:25	8:31	0	0	26	10:25	10:31	10	0.4
7	8:31	8:37	10	0.4	27	10:31	10:37	0	0
8	8:37	8:43	20	0.8	28	10:37	10:43	0	0
9	8:43	8:49	135	5.6	29	10:43	10:49	0	0
10	8:49	8:55	130	5.4	30	10:49	10:55	0	0
11	8:55	9:01	130	5.4	31	10:55	11:01	0	0
12	9:01	9:07	50	2.1	32	11:01	11:07	0	0
13	9:07	9:13	0	0	33	11:07	11:13	0	0
14	9:13	9:19	0	0	34	11:13	11:19	0	0
15	9:19	9:25	45	1.9	35	11:19	11:25	10	0.4
16	9:25	9:31	0	0	36	11:25	11:31	5	0.2
17	9:31	9:37	0	0	37	11:31	11:37	0	0
18	9:37	9:43	5	0.2	38				
19	9:43	9:49	10	0.4	39				
20	9:49	9:55	20	0.8	40				

Sketch showing how opacity varied with time:

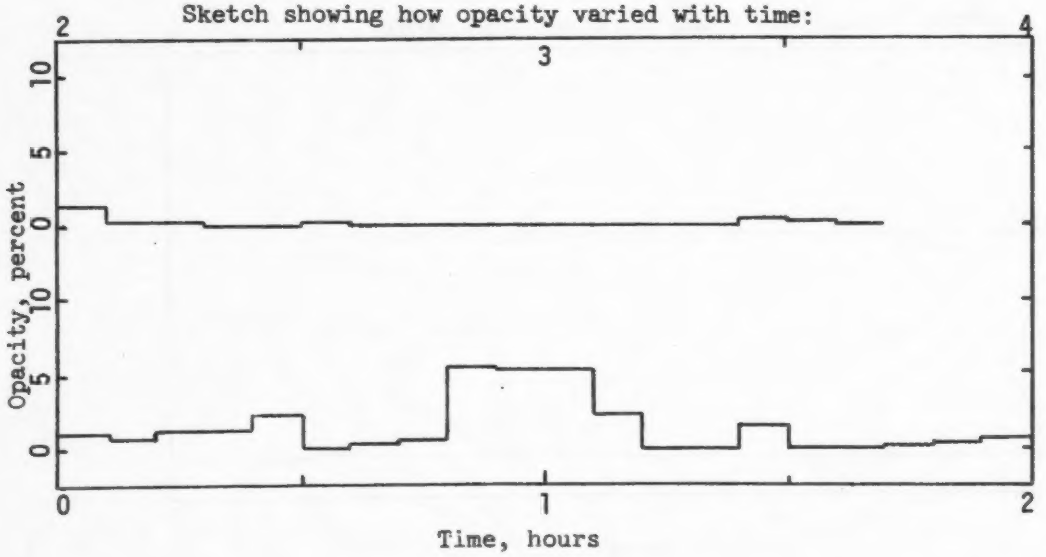


Table C-22

FACILITY: B

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 9, 1974
Type of Discharge: Particulates Height of Point of Discharge: 3 ft. Above Roof
Location of Discharge: Roof Vent Height of Observation Point:
Distance from Observer to Discharge Point: Duration: 3 hrs., 40 min.
Direction of Observer from Discharge Point: 30 ft. South of Discharge Point
Descript. of Background: Sky Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Scattered Clouds Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	8:00	8:06	0	0	21	10:00	10:06	0	0
2	8:06	8:12	0	0	22	10:06	10:12	0	0
3	8:12	8:18	0	0	23	10:12	10:18	0	0
4	8:18	8:24	0	0	24	10:18	10:24	0	0
5	8:24	8:30	0	0	25	10:24	10:30	0	0
6	8:30	8:36	0	0	26	10:30	10:36	0	0
7	8:36	8:42	0	0	27	10:36	10:42	0	0
8	8:42	8:48	0	0	28	10:42	10:48	0	0
9	8:48	8:54	0	0	29	10:48	10:54	0	0
10	8:54	9:00	0	0	30	10:54	11:00	0	0
11	9:00	9:06	0	0	31	11:00	11:06	0	0
12	9:06	9:12	0	0	32	11:06	11:12	0	0
13	9:12	9:18	15	0.6	33	11:12	11:18	0	0
14	9:18	9:24	0	0	34	11:18	11:24	0	0
15	9:24	9:30	0	0	35	11:24	11;30	0	0
16	9:30	9:36	0	0	36	11:30	11:36	0	0
17	9:36	9:42	15	0.6	37	11:36	11:40	0	0
18	9:42	9:48	0	0	38				
19	9:48	9:54	0	0	39				
20	9:54	10:00	0	0	40				

Sketch showing how opacity varied with time:

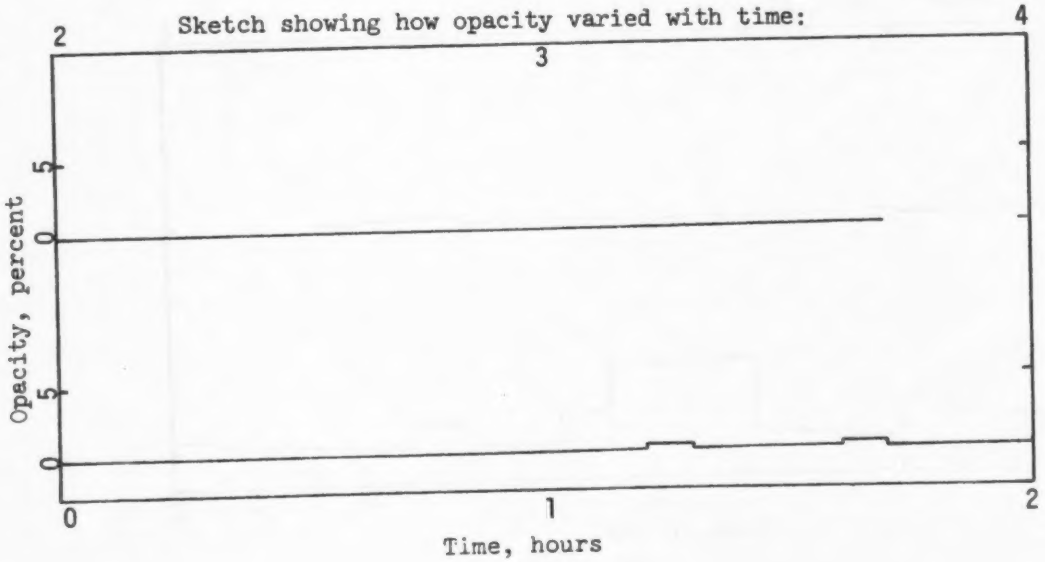


Table C-23

FACILITY: B
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 9, 1974
Type of Discharge: Particulates Height of Point of Discharge: 50 ft.
Location of Discharge: Stack Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 125 ft. Duration: 3 hrs., 39 min.
Direction of Observer from Discharge Point: South-East
Descript. of Background: Gray Bldgs. & Equipment Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1:20	1:26	5	0.2	21	3:20	3:26	75	3.1
2	1:26	1:32	0	0	22	3:26	3:32	25	1.0
3	1:32	1:38	0	0	23	3:32	3:38	0	0
4	1:38	1:44	0	0	24	3:38	3:44	0	0
5	1:44	1:50	60	2.5	25	3:44	3:50	105	4.4
6	1:50	1:56	0	0	26	3:50	3:56	150	6.2
7	1:56	2:02	0	0	27	3:56	4:02	85	3.5
8	2:02	2:08	0	0	28	4:02	4:08	0	0
9	2:08	2:14	0	0	29	4:08	4:14	0	0
10	2:14	2:20	0	0	30	4:14	4:20	75	3.1
11	2:20	2:26	0	0	31	4:20	4:26	180	7.5
12	2:26	2:32	32	1.3	32	4:26	4:32	150	6.2
13	2:32	2:38	0	0	33	4:32	4:38	90	3.7
14	2:38	2:44	85	3.5	34	4:38	4:44	120	5.0
15	2:44	2:50	95	4.0	35	4:44	4:50	275	11.5
16	2:50	2:56	5	0.2	36	4:50	4:56	225	9.4
17	2:56	3:02	0	0	37	4:56	4:59	65	5.4
18	3:02	3:08	0	0	38				
19	3:08	3:14	0	0	39				
20	3:14	3:20	10	0.4	40				

Sketch showing how opacity varied with time:

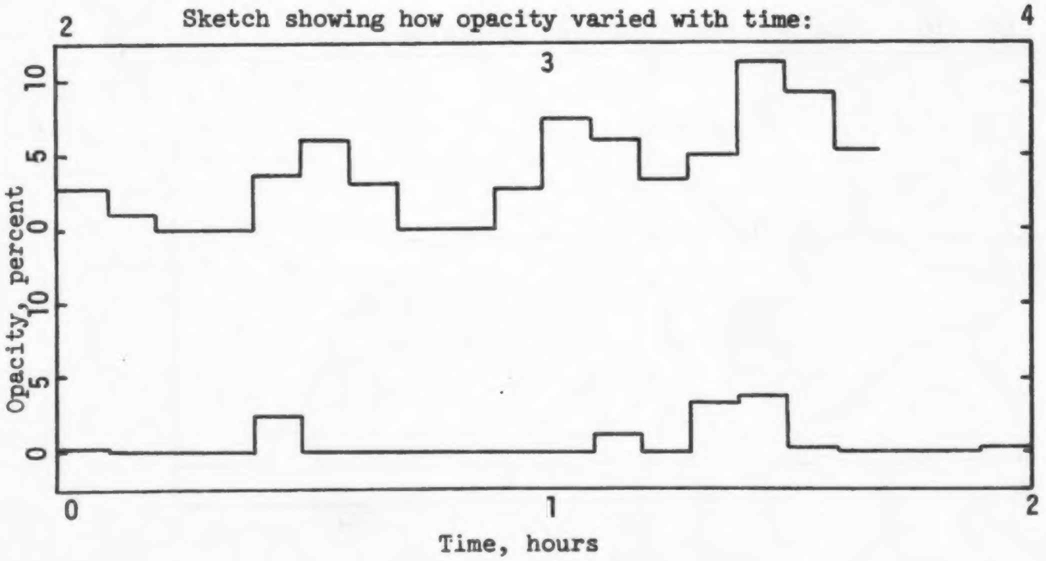


Table C-24

FACILITY: B
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: July 9, 1974
Type of Discharge: Particulates Height of Point of Discharge: 3 ft. Above Roof
Location of Discharge: Roof Vent Height of Observation Point: At Vent Level
Distance from Observer to Discharge Point: 30 ft. Duration: 3 hrs., 35 min.
Direction of Observer from Discharge Point: 30 ft. South of Discharge Point
Descript. of Background: Sky Wind Direction: Calm Color of Plume: Brown
Descript. of Sky: Clear Wind Velocity: Not Rec. Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1:30	1:36	0	0	21	3:30	3:36	0	0
2	1:36	1:42	0	0	22	3:36	3:42	0	0
3	1:42	1:48	0	0	23	3:42	3:48	0	0
4	1:48	1:54	0	0	24	3:48	3:54	0	0
5	1:54	2:00	0	0	25	3:54	4:00	0	0
6	2:00	2:06	0	0	26	4:00	4:06	0	0
7	2:06	2:12	0	0	27	4:06	4:12	0	0
8	2:12	2:18	0	0	28	4:12	4:18	30	1.2
9	2:18	2:24	0	0	29	4:18	4:24	0	0
10	2:24	2:30	0	0	30	4:24	4:30	0	0
11	2:30	2:36	0	0	31	4:30	4:36	0	0
12	2:36	2:42	0	0	32	4:36	4:42	0	0
13	2:42	2:48	0	0	33	4:42	4:48	0	0
14	2:48	2:54	0	0	34	4:48	4:54	0	0
15	2:54	3:00	0	0	35	4:54	5:00	0	0
16	3:00	3:06	0	0	36	5:00	5:05	0	0
17	3:06	3:12	0	0	37				
18	3:12	3:18	55	2.3	38				
19	3:18	3:24	0	0	39				
20	3:24	3:30	0	0	40				

Sketch showing how opacity varied with time:

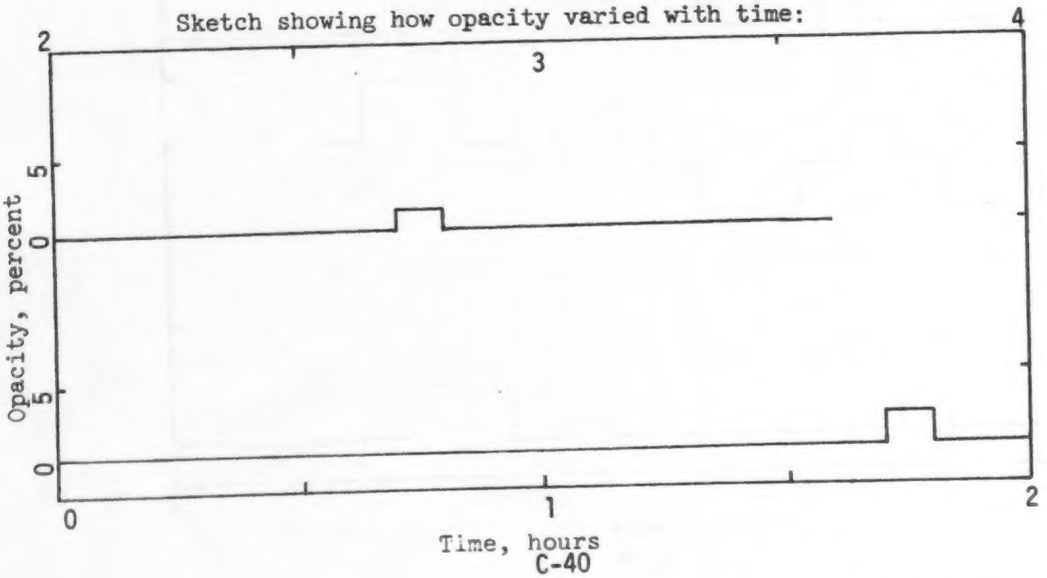


Table C-25

FACILITY: C

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 18, 1974
Type of Discharge: Particulates Height of Point of Discharge: 15 ft. Above Roof
Location of Discharge: Stack Height of Observation Point: Even with Stacktop
Distance from Observer to Discharge Point: 20 ft. Duration: 2 hrs., 8 min.
Direction of Observer from Discharge Point: Roof, N.W. of Stack
Descript. of Background: Sky Wind Direction: N.W. Color of Plume: Brown
Descript. of Sky: 100% Overcast Wind Velocity: 0-5 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	11:30	11:36	285	11.9	21	1:30	1:36	65	2.7
2	11:36	11:42	135	5.6	22	1:36	1:38	0	0
3	11:42	11:48	10	0.4	23				
4	11:48	11:54	20	0.8	24				
5	11:54	12:00	20	0.8	25				
6	12:00	12:06	5	0.2	26				
7	12:06	12:12	15	0.6	27				
8	12:12	12:18	25	1.0	28				
9	12:18	12:24	125	5.2	29				
10	12:24	12:30	210	8.8	30				
11	12:30	12:36	245	10.2	31				
12	12:36	12:42	145	6.0	32				
13	12:42	12:48	185	7.7	33				
14	12:48	12:54	130	5.4	34				
15	12:54	1:00	40	1.7	35				
16	1:00	1:06	70	2.9	36				
17	1:06	1:12	35	1.5	37				
18	1:12	1:18	20	0.8	38				
19	1:18	1:24	0	0	39				
20	1:24	1:30	40	1.7	40				

Sketch showing how opacity varied with time:

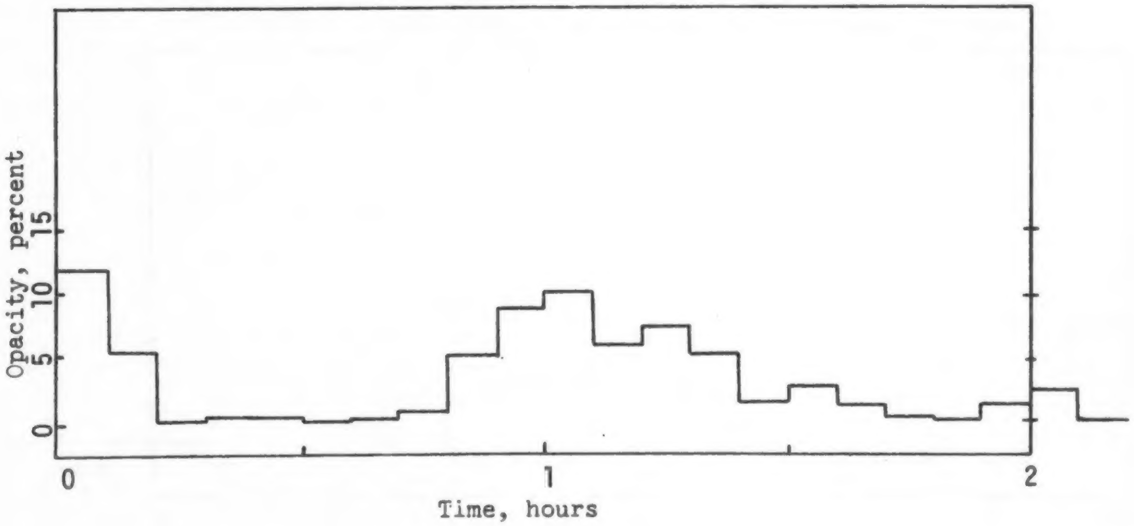


Table C-26

FACILITY: C

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 18, 1974
Type of Discharge: Particulates Height of Point of Discharge: 15 ft.
Location of Discharge: Stack Height of Observation Point: Even with Stack Top
Distance from Observer to Discharge Point: 30 ft. Duration: 2 hrs., 8 min.
Direction of Observer from Discharge Point: North-West of Stack
Descript. of Background: Sky Wind Direction: N.W. Color of Plume: Brown
Descript. of Sky: 100% Overcast Wind Velocity: 0-5 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	11:30	11:36	260	10.8	21	1:30	1:36	55	2.3
2	11:36	11:42	130	5.4	22	1:36	1:38	0	0
3	11:42	11:48	0	0	23				
4	11:48	11:54	20	0.8	24				
5	11:54	12:00	0	0	25				
6	12:00	12:06	0	0	26				
7	12:06	12:12	0	0	27				
8	12:12	12:18	40	1.7	28				
9	12:18	12:24	120	5.0	29				
10	12:24	12:30	240	10.0	30				
11	12:30	12:36	200	8.3	31				
12	12:36	12:42	150	6.2	32				
13	12:42	12:48	155	6.5	33				
14	12:48	12:54	120	5.0	34				
15	12:54	1:00	25	1.0	35				
16	1:00	1:06	90	3.8	36				
17	1:06	1:12	15	0.6	37				
18	1:12	1:18	15	0.6	38				
19	1:18	1:24	5	0.2	39				
20	1:24	1:30	50	2.1	40				

Sketch showing how opacity varied with time:

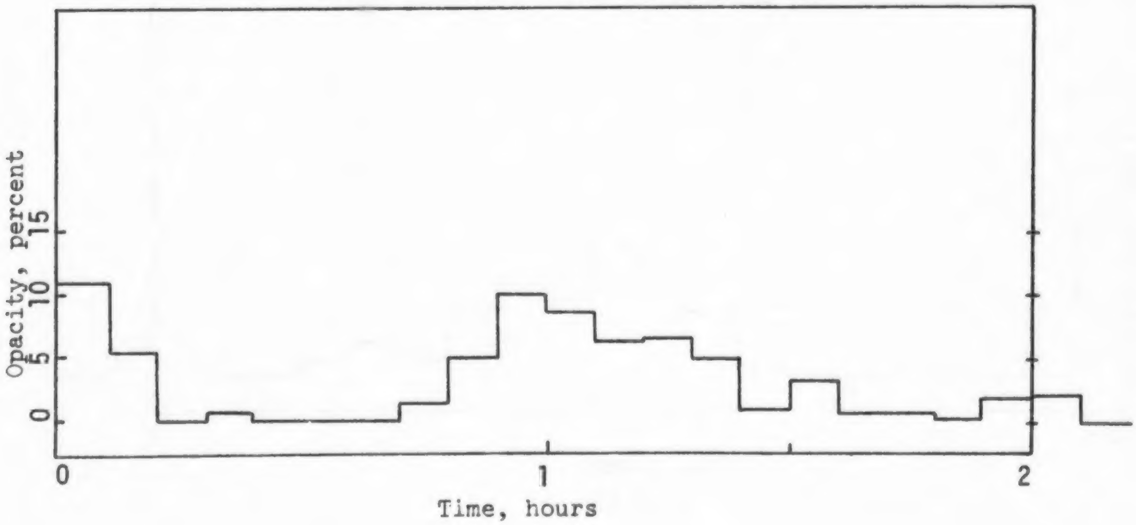


Table C-27

FACILITY: C

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 18, 1974

Type of Discharge: Particulates Height of Point of Discharge: 15 ft. Above Roof

Location of Discharge: Stack Height of Observation Point: Even with Stack

Distance from Observer to Discharge Point: 20 ft. Duration: 1 hr., 24 min.

Direction of Observer from Discharge Point: Roof N.W. of Stack

Descript. of Background: Sky Wind Direction: N.W. Color of Plume: Brown

Descript. of Sky: 95% Overcast Wind Velocity: 0-5 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	2:00	2:06	505	21.0	21				
2	2:06	2:12	45	1.9	22				
3	2:12	2:18	70	2.9	23				
4	2:18	2:24	15	0.6	24				
5	2:24	2:30	5	0.2	25				
6	2:30	2:36	105	4.4	26				
7	2:36	2:42	30	1.3	27				
8	2:42	2:48	125	5.2	28				
9	2:48	2:54	0	0	29				
10	2:54	3:00	140	5.8	30				
11	3:00	3:06	315	13.1	31				
12	3:06	3:12	150	6.2	32				
13	3:12	3:18	155	6.5	33				
14	3:18	3:24	160	6.7	34				
15					35				
16					36				
17					37				
18					38				
19					39				
20					40				

Sketch showing how opacity varied with time:

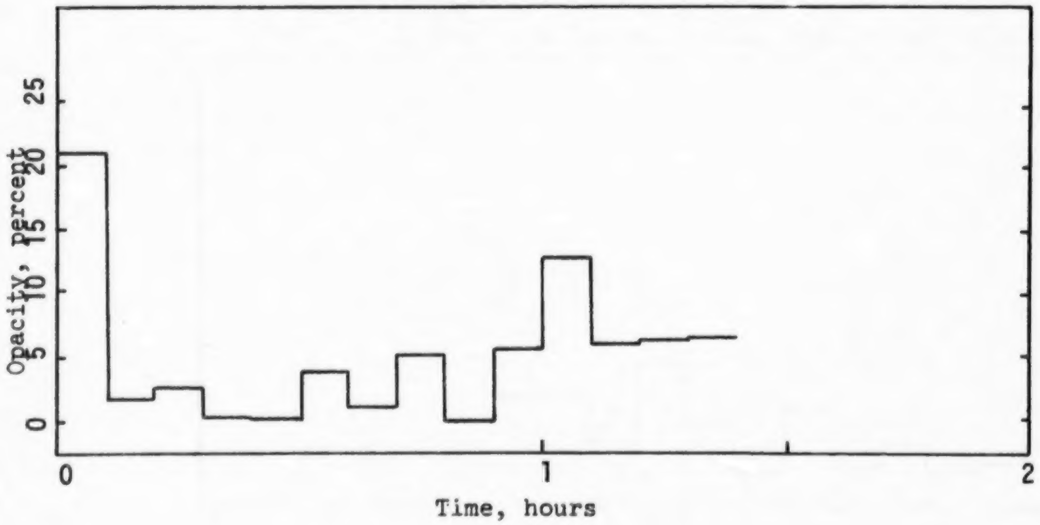


Table C-28

FACILITY: C

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 18, 1974

Type of Discharge: Particulates Height of Point of Discharge: 15 ft.

Location of Discharge: Stack Height of Observation Point: Even with Stack Top

Distance from Observer to Discharge Point: 30 ft. Duration: 1 hr., 24 min.

Direction of Observer from Discharge Point: 30 ft. N.W. of Stack

Descript. of Background: Sky Wind Direction: N.W. Color of Plume: Brown

Descript. of Sky: 95% Overcast Wind Velocity: 0-5 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	2:00	2:06	495	20.6	21				
2	2:06	2:12	35	1.5	22				
3	2:12	2:18	70	2.9	23				
4	2:18	2:24	25	1.0	24				
5	2:24	2:30	0	0	25				
6	2:30	2:36	75	3.1	26				
7	2:36	2:42	20	0.8	27				
8	2:42	2:48	120	5.0	28				
9	2:48	2:54	0	0	29				
10	2:54	3:00	95	4.0	30				
11	3:00	3:06	215	9.0	31				
12	3:06	3:12	70	2.9	32				
13	3:12	3:18	135	5.6	33				
14	3:18	3:24	145	6.0	34				
15					35				
16					36				
17					37				
18					38				
19					39				
20					40				

Sketch showing how opacity varied with time:

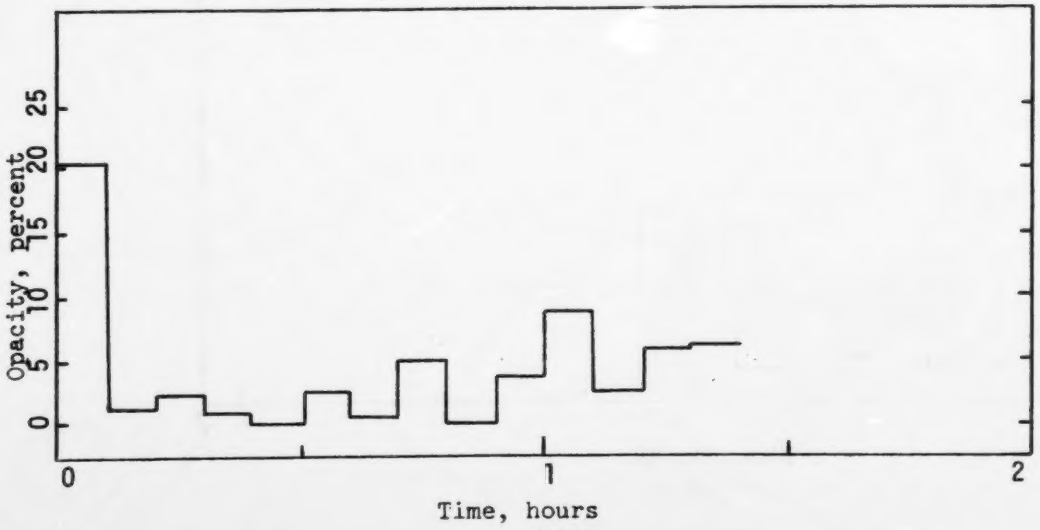


Table C-29

FACILITY: C
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 19, 1974
Type of Discharge: Particulates Height of Point of Discharge: 15 ft. Above Flat Roof
Location of Discharge: Stack Height of Observation Point: 20 ft. Above Base of Stk.
Distance from Observer to Discharge Point: 30 ft. Duration: 2 hrs., 14 min.
Direction of Observer from Discharge Point: 30 ft. Roof, East of Stack
Descript. of Background: ________ Wind Direction: S.E. Color of Plume: Brown
Descript. of Sky: Clear and Sunny Wind Velocity: 0-5 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	8:30	8:36	290	12.1	21	10:30	10:36	25	1.0
2	8:36	8:42	5	0.2	22	10:36	10:42	15	0.6
3	8:42	8:48	5	0.2	23	10:42	10:44	0	0
4	8:48	8:54	0	0	24				
5	8:54	9:00	0	0	25				
6	9:00	9:06	0	0	26				
7	9:06	9:12	40	1.7	27				
8	9:12	9:18	40	1.7	28				
9	9:18	9:24	80	3.3	29				
10	9:24	9:30	10	0.4	30				
11	9:30	9:36	60	2.5	31				
12	9:36	9:42	55	2.3	32				
13	9:42	9:48	75	3.1	33				
14	9:48	9:54	20	0.8	34				
15	9:54	10:00	80	3.3	35				
16	10:00	10:06	325	13.5	36				
17	10:06	10:12	650	27.1	37				
18	10:12	10:18	730	30.4	38				
19	10:18	10:24	140	5.8	39				
20	10:24	10:30	10	0.4	40				

Sketch showing how opacity varied with time:

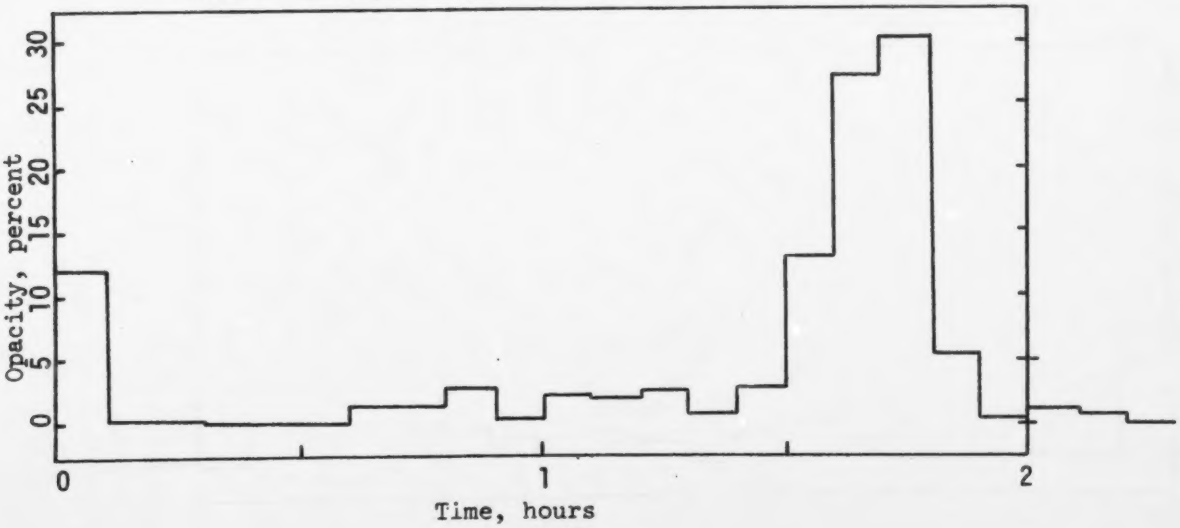


Table C-30

FACILITY: C

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: September 19, 1974
Type of Discharge: Particulates Height of Point of Discharge: 15 ft.
Location of Discharge: Stack Height of Observation Point: Even with Base of Stack
Distance from Observer to Discharge Point: 30 ft. Duration: 2 hrs., 16 min.
Direction of Observer from Discharge Point: 30 ft. East of Stack
Descript. of Background: Sky Wind Direction: S.E. Color of Plume: Brown
Descript. of Sky: Clear and Sunny Wind Velocity: 0-5 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	8:30	8:36	245	10.2	21	10:30	10:36	10	0.4
2	8:36	8:42	0	0	22	10:36	10:42	5	0.2
3	8:42	8:48	5	0.2	23	10:42	10:46	0	0
4	8:48	8:54	0	0	24				
5	8:54	9:00	0	0	25				
6	9:00	9:06	0	0	26				
7	9:06	9:12	45	1.9	27				
8	9:12	9:18	15	0.6	28				
9	9:18	9:24	60	2.5	29				
10	9:24	9:30	0	0	30				
11	9:30	9:36	45	1.9	31				
12	9:36	9:42	70	2.9	32				
13	9:42	9:48	55	2.3	33				
14	9:48	9:54	20	0.8	34				
15	9:54	10:00	80	3.3	35				
16	10:00	10:06	335	14.0	36				
17	10:06	10:12	605	25.2	37				
18	10:12	10:18	680	28.3	38				
19	10:18	10:24	140	5.8	39				
20	10:24	10:30	5	0.2	40				

Sketch showing how opacity varied with time:

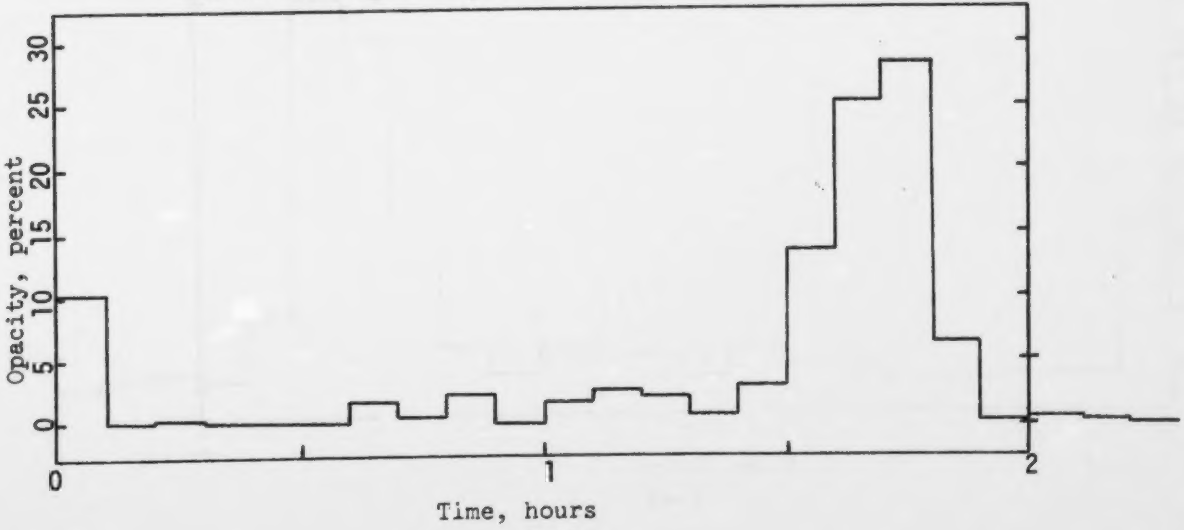


Table C-31

FACILITY: D

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 1, 1974
Type of Discharge: Dust Height of Point of Discharge: 20 ft.
Location of Discharge: Baghouse Outlet Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 50 ft. Duration: 87 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: East Color of Plume: White
Descript. of Sky: Overcast Wind Velocity: 3 to 5 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	3:20	3:26	0	0	21				
2	3:26	3:32	0	0	22				
3	3:32	3:38	0	0	23				
4	3:38	3:44	0	0	24				
5	3:44	3:50	0	0	25				
6	3:50	3:56	0	0	26				
7	3:56	4:02	0	0	27				
8	4:02	4:08	0	0	28				
9	4:08	4:14	0	0	29				
10	4:14	4:20	0	0	30				
11	4:20	4:26	0	0	31				
12	4:26	4:32	0	0	32				
13	4:32	4:38	0	0	33				
14	4:38	4:44	0	0	34				
15	4:44	4:47	0	0	35				
16					36				
17					37				
18					38				
19					39				
20					40				

Sketch showing how opacity varied with time:

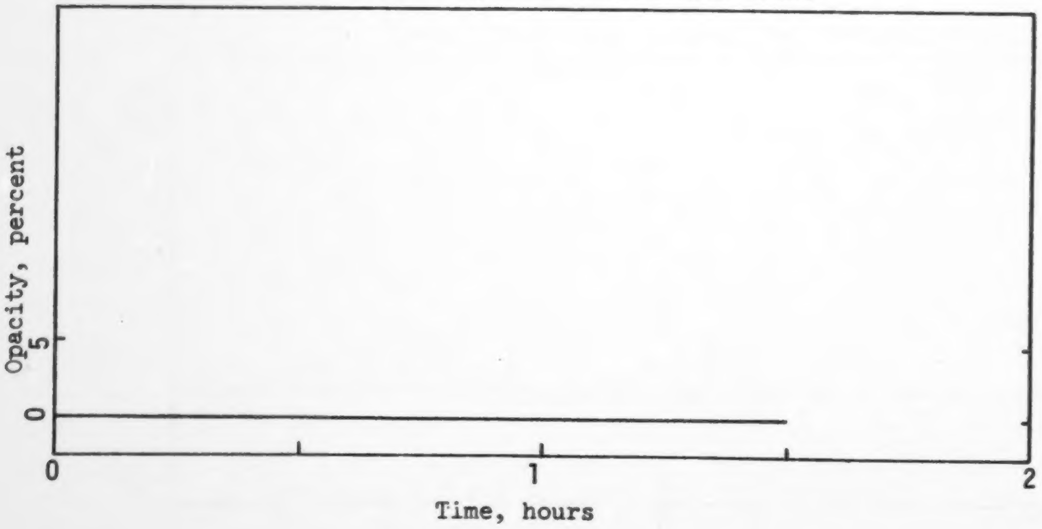


Table C-32

FACILITY: D

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 1, 1974
Type of Discharge: Furnace Roof Exhaust Height of Point of Discharge: 80 ft.
Location of Discharge: Fur. Roof Exhaust Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 90 ft. Duration: 120 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: East Color of Plume: White
Descript. of Sky: Overcast-Part.Cldy Wind Velocity: 3 to 5 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	3:20	3:26	120	5.0	21				
2	3:26	3:32	120	5.0	22				
3	3:32	3:38	120	5.0	23				
4	3:38	3:44	120	5.0	24				
5	3:44	3:50	120	5.0	25				
6	3:50	3:56	120	5.0	26				
7	3:56	4:02	120	5.0	27				
8	4:02	4:08	120	5.0	28				
9	4:08	4:14	175	7.3	29				
10	4:14	4:20	120	5.0	30				
11	4:20	4:26	120	5.0	31				
12	4:26	4:32	120	5.0	32				
13	4:32	4:38	120	5.0	33				
14	4:38	4:44	120	5.0	34				
15	4:44	4:50	120	5.0	35				
16	4:50	4:56	135	5.6	36				
17	4:56	5:02	120	5.0	37				
18	5:02	5:08	120	5.0	38				
19	5:08	5:14	120	5.0	39				
20	5:14	5:20	120	5.0	40				

Sketch showing how opacity varied with time:

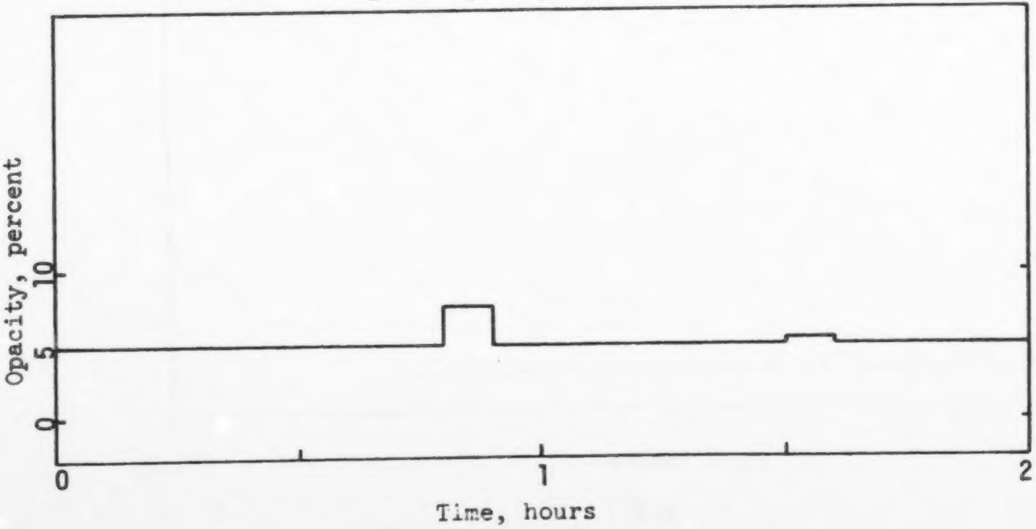


Table C-33

FACILITY: D
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 2, 1974
Type of Discharge: Dust Height of Point of Discharge: 20 ft.
Location of Discharge: Baghouse Outlet Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 50 ft. Duration: 210 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: South Color of Plume: White
Descript. of Sky: Partly Cloudy Wind Velocity: 20 to 30 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1 A.M.	9:25	9:31	0	0	21	4:04	4:10	0	0
2	9:31	9:37	0	0	22	4:10	4:16	0	0
3	9:37	9:55	No Readings		23	4:16	4:22	0	0
4	9:55	10:01	0	0	24	4:22	4:28	0	0
5	10:01	10:07	0	0	25	4:28	4:34	0	0
6	10:07	10:13	0	0	26	4:34	4:39	0	0
7	10:13	10:15	0	0	27	4:39	4:48	No Readings	
8	10:15	10:21	No Readings		28	4:48	4:54	0	0
9	10:21	10:27	10	0.4	29	4:54	5:00	0	0
10	10:27	10:39	No Readings		30	5:00	5:06	0	0
11	10:39	10:41	5	0.6	31	5:06	5:12	0	0
12 P.M.	3:10	3:16	0	0	32	5:12	5:18	0	0
13	3:16	3:22	0	0	33	5:18	5:24	0	0
14	3:22	3:28	0	0	34	5:24	5:30	0	0
15	3:28	3:34	0	0	35	5:30	5:36	0	0
16	3:34	3:40	0	0	36	5:36	5:42	0	0
17	3:40	3:46	0	0	37	5:42	5:48	0	0
18	3:46	3:52	0	0	38	5:48	5:54	0	0
19	3:52	3:58	0	0	39	5:54	6:00	0	0
20	3:58	4:04	0	0	40	6:00	6:06	0	0
					41	6:06	6:10	0	0

Sketch showing how opacity varied with time:

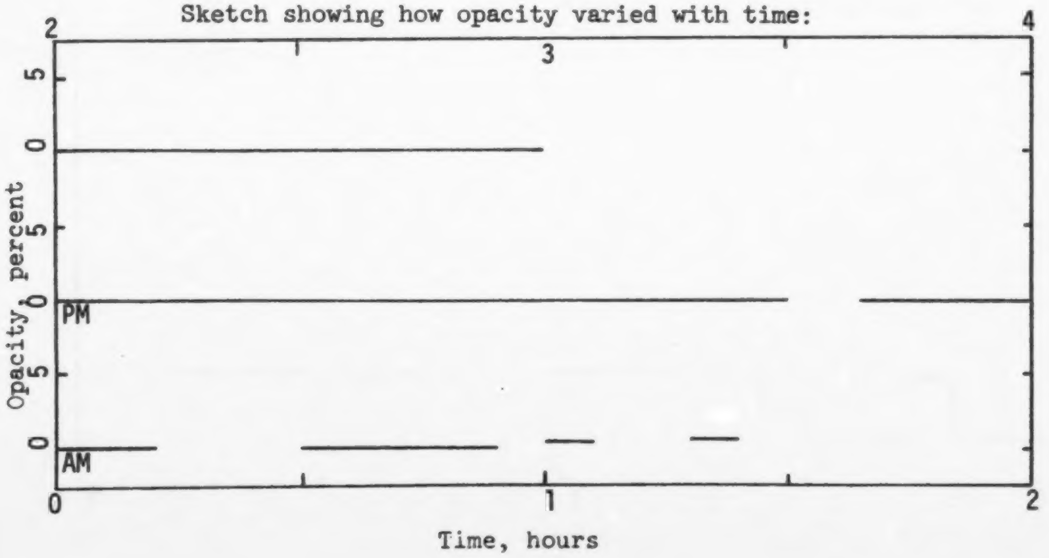


Table C-34

FACILITY: D

SUMMARY OF VISIBLE EMISSIONS

Type of Plant:	Gray Iron Foundry	Date:	October 2, 1974
Type of Discharge:	Dust	Height of Point of Discharge:	80 ft.
Location of Discharge:	Furnace Roof Exst.	Height of Observation Point:	Ground Level
Distance from Observer to Discharge Point:	90 ft.	Duration:	120 min.

Direction of Observer from Discharge Point: South

Descript. of Background:	Sky	Wind Direction:	South	Color of Plume:	White
Descript. of Sky:	Clear, Sct. Clds.	Wind Velocity:	20 to 30	Detached Plume:	No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	9:25	9:31	5	0.2	21				
2	9:31	9:37	10	0.4	22				
3	9:37	9:43	110	4.6	23				
4	9:43	9:49	0	0	24				
5	9:49	9:55	0	0	25				
6	9:55	10:01	65	2.7	26				
7	10:01	10:07	120	5.0	27				
8	10:07	10:13	120	5.0	28				
9	10:13	10:19	120	5.0	29				
10	10:19	10:25	120	5.0	30				
11	10:25	10:31	120	5.0	31				
12	10:31	10:37	120	5.0	32				
13	10:37	10:43	120	5.0	33				
14	10:43	10:49	120	5.0	34				
15	10:49	10:55	120	5.0	35				
16	10:55	11:01	120	5.0	36				
17	11:01	11:07	120	5.0	37				
18	11:07	11:13	120	5.0	38				
19	11:13	11:19	120	5.0	39				
20	11:19	11:25	120	5.0	40				

Sketch showing how opacity varied with time:

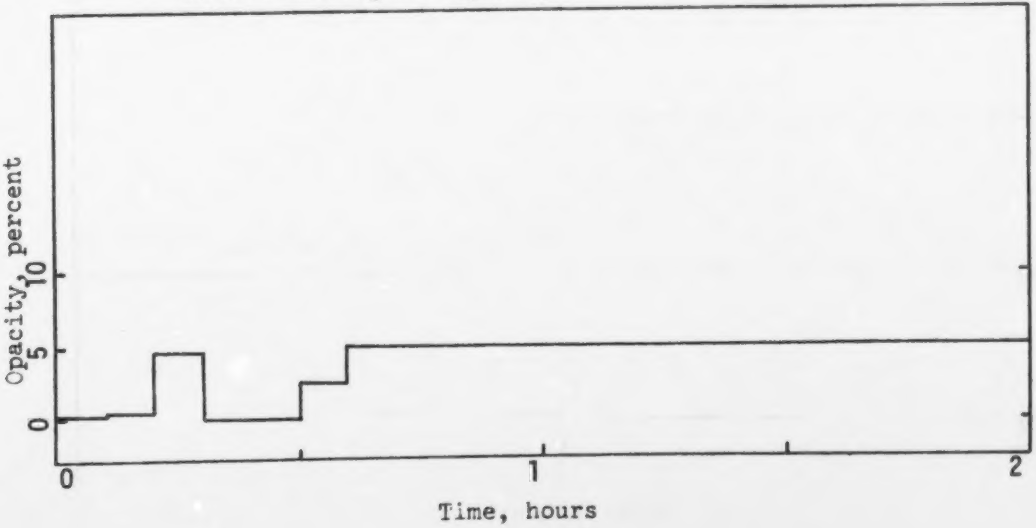


Table C-35

FACILITY: D

SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 2, 1974
Type of Discharge: Dust Height of Point of Discharge: 80 ft.
Location of Discharge: Furnace Roof Exst. Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 90 ft. Duration: 180 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: South Color of Plume: White
Descript. of Sky: Clear, Scat. Clds. Wind Velocity: 20 to 30 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	3:10	3:16	120	5.0	21	5:10	5:16	120	5.0
2	3:16	3:22	120	5.0	22	5:16	5:22	120	5.0
3	3:22	3:28	120	5.0	23	5:22	5:28	120	5.0
4	3:28	3:34	120	5.0	24	5:28	5:34	120	5.0
5	3:34	3:40	120	5.0	25	5:34	5:40	120	5.0
6	3:40	3:46	120	5.0	26	5:40	5:46	120	5.0
7	3:46	3:52	120	5.0	27	5:46	5:52	120	5.0
8	3:52	3:58	120	5.0	28	5:52	5:58	120	5.0
9	3:58	4:04	120	5.0	29	5:58	6:04	120	5.0
10	4:04	4:10	120	5.0	30	6:04	6:10	120	5.0
11	4:10	4:16	120	5.0	31				
12	4:16	4:22	120	5.0	32				
13	4:22	4:28	150	6.3	33				
14	4:28	4:34	140	5.8	34				
15	4:34	4:40	120	5.0	35				
16	4:40	4:46	165	6.9	36				
17	4:46	4:52	150	6.3	37				
18	4:52	4:58	120	5.0	38				
19	4:58	5:04	120	5.0	39				
20	5:04	5:10	120	5.0	40				

Sketch showing how opacity varied with time:

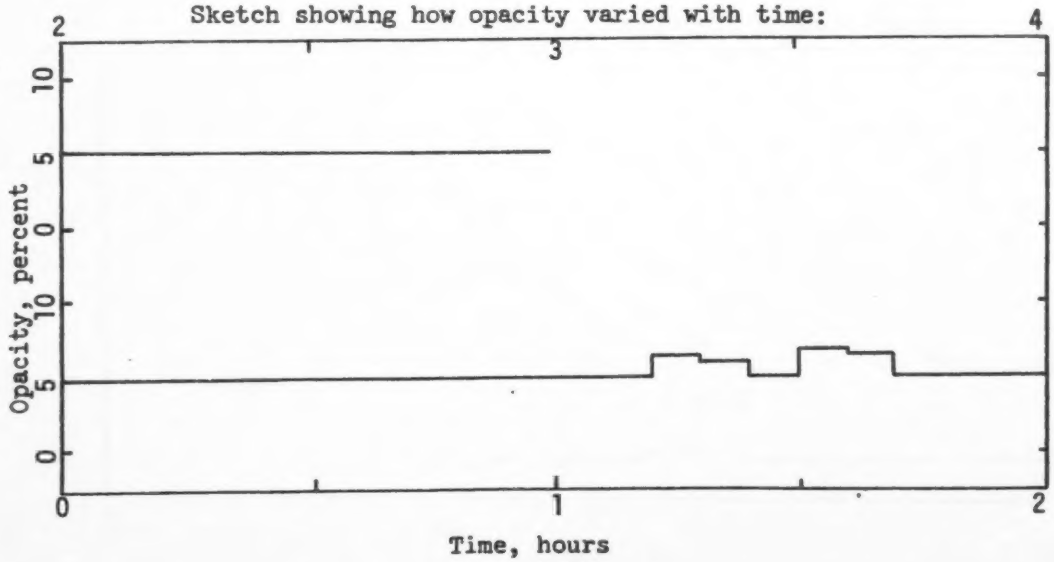


Table C-36

FACILITY: D
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 3, 1974
Type of Discharge: Dust Height of Point of Discharge: 20 ft.
Location of Discharge: Baghouse Outlet Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 50 ft. Duration: 82 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: S.W. Color of Plume: White
Descript. of Sky: Partly Cloudy Wind Velocity: 20 to 35 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	9:18	9:24	0	0	21				
2	9:24	9:30	0	0	22				
3	9:30	9:36	0	0	23				
4	9:36	9:42	0	0	24				
5	9:42	9:48	0	0	25				
6	9:48	9:54	0	0	26				
7	9:54	10:00	0	0	27				
8	10:00	10:06	100	4.2	28				
9	10:06	10:12	20	0.8	29				
10	10:12	10:18	0	0	30				
11	10:18	10:24	0	0	31				
12	10:24	10:29	0	0	32				
13	10:29	10:52	No Readings		33				
14	10:52	10:58	120	5.0	34				
15	10:58	11:03	100	5.0	35				
16					36				
17					37				
18					38				
19					39				
20					40				

Sketch showing how opacity varied with time:

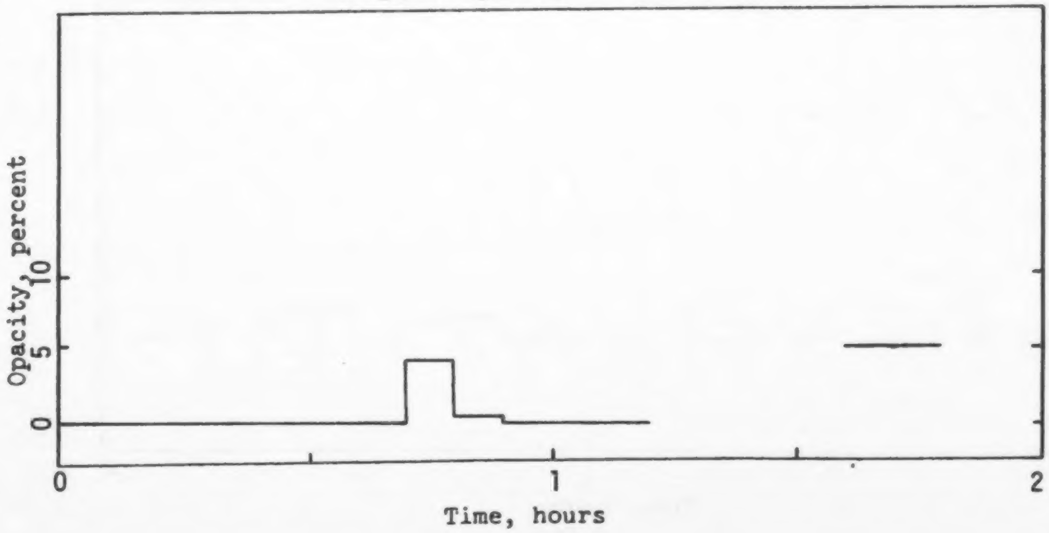


Table C-37

FACILITY: D
SUMMARY OF VISIBLE EMISSIONS

Type of Plant: Gray Iron Foundry Date: October 3, 1974
Type of Discharge: Dust Height of Point of Discharge: 80 ft.
Location of Discharge: Furnace Roof Exst. Height of Observation Point: Ground Level
Distance from Observer to Discharge Point: 90 ft. Duration: 63 min.
Direction of Observer from Discharge Point: South
Descript. of Background: Sky Wind Direction: S.W. Color of Plume: White
Descript. of Sky: Partly Cloudy Wind Velocity: 20 to 35 Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	9:03	9:09	0	0	21				
2	9:09	9:15	20	0.8	22				
3	9:15	9:18	20	1.7	23				
4	9:18	10:47	No Readings		24				
5	10:47	10:53	120	5.0	25				
6	10:53	10:57	80	5.0	26				
7	10:57	11:08	No Readings		27				
8	11:08	11:14	120	5.0	28				
9	11:14	11:20	120	5.0	29				
10	11:20	11:26	120	5.0	30				
11	11:26	11:32	120	5.0	31				
12	11:32	11:38	120	5.0	32				
13	11:38	11:44	120	5.0	33				
14	11:44	11:46	40	5.0	34				
15					35				
16					36				
17					37				
18					38				
19					39				
20					40				

Sketch showing how opacity varied with time:

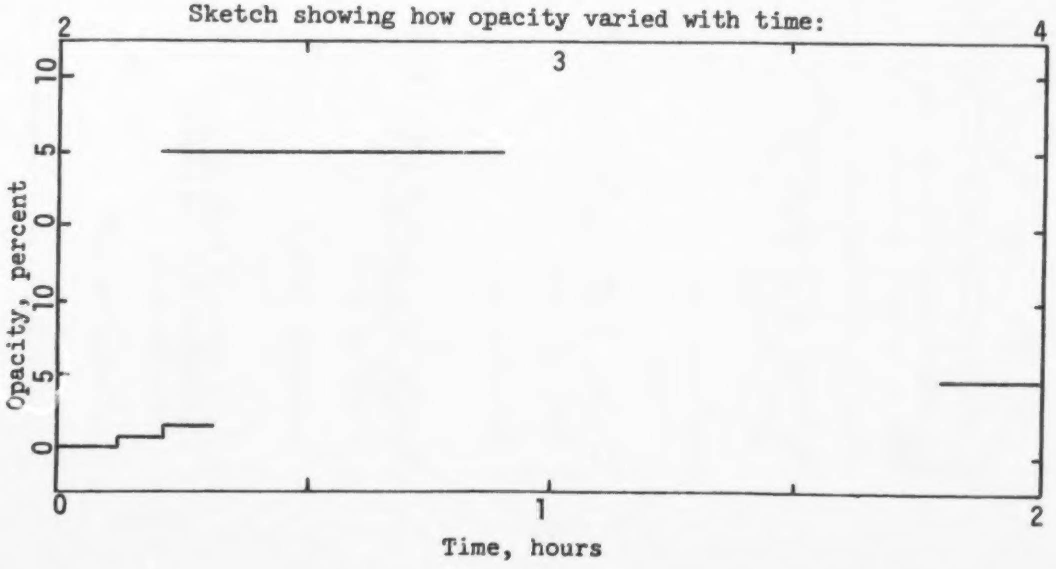


TABLE C-38. SUMMARY OF GASEOUS RESULTS
FACILITY A

Run number Date	Units	1 6-19-74	2 6-19-74	3 6-20-74	Average
Carbon monoxide emissions					
Concentration (average)	ppm (volume)	95	88	104	96
Emission rate	lb/h	34.4	30.8	37.0	34.1
	kg/h	15.6	14.0	16.8	15.5
Emission factor	lb/ton	1.25	0.93	1.30	1.16
	kg/Mg	0.62	0.47	0.65	0.58
Nitrogen oxide (as NO_2) emissions					
Concentration (average)	ppm (volume)	3.38	1.59	--	2.49
Emission rate	lb/h	1.89	0.95	--	1.37
	kg/h	0.86	0.39	--	0.62
Emission factor	lb/ton	0.068	0.026	--	0.047
	kg/Mg	0.034	0.013	--	0.024
Hydrocarbon (as CH_4) emissions					
Concentration (average)	ppm (volume)	7.4	7.8	7.6	7.6
Emission rate	lb/h	1.53	1.56	1.54	1.54
	kg/h	0.69	0.71	0.70	0.70
Emission factor	lb/ton	0.055	0.047	0.054	0.052
	kg/Mg	0.028	0.024	0.027	0.026
Sulfur dioxide emissions					
Concentration (average)	ppm (volume)	4.86	5.26	4.40	4.84
Emission rate	lb/h	3.78	3.93	3.32	3.68
	kg/h	1.71	1.78	1.51	1.67
Emission factor	lb/ton	0.137	0.119	0.117	0.124
	kg/Mg	0.068	0.060	0.059	0.062

TABLE C-39. SUMMARY OF GASEOUS RESULTS
FACILITY B

Run number Date	Units	1 7-8-74	2 7-9-74	3 7-9-74	Average
Carbon monoxide emissions					
Concentration (average)	ppm (volume)	75	84	59	73
Emission rate	lb/h	22.4	26.5	17.6	22.2
	kg/h	10.2	12.0	8.0	10.1
Emission factor	lb/ton	0.72	0.86	0.53	0.70
	kg/Mg	0.36	0.43	0.27	0.35
Nitrogen oxide (as NO_2) emissions					
Concentration (average)	ppm (volume)	3.25	51.0	--	27.1
Emission rate	lb/h	1.51	25.0	--	13.3
	kg/h	0.69	11.3	--	6.0
Emission factor	lb/ton	0.048	0.779	--	0.41
	kg/Mg	0.024	0.388	--	0.21
Hydrocarbon (as CH_4) emissions					
Concentration (average)	ppm (volume)	8.6	9.6	11.5	9.9
Emission rate	lb/h	1.47	1.73	1.96	1.91
	kg/h	0.73	0.85	0.97	0.94
Emission factor	lb/ton	0.047	0.056	0.059	0.054
	kg/Mg	0.026	0.030	0.032	0.029
Sulfur dioxide emissions					
Concentration (average)	ppm (volume)	2.88	0.66	1.37	1.64
Emission rate	lb/h	1.86	0.45	0.88	1.06
	kg/h	0.84	0.20	0.40	0.48
Emission factor	lb/ton	0.060	0.015	0.027	0.034
	kg/Mg	0.030	0.007	0.013	0.017

TABLE C-40. SUMMARY OF GASEOUS RESULTS
FACILITY C

Run number		1	2	3	Average
Date	Units	9-18-74	9-18-74	9-19-74	
Carbon monoxide emissions					
Concentration (average)	ppm (volume)	106	92	137	112
Emission rate	lb/h	5.60	2.85	4.35	4.27
	kg/h	2.54	1.29	1.97	1.94
Emission factor	lb/ton	1.56	0.73	1.06	1.12
	kg/Mg	0.77	0.37	0.53	0.56
Nitrogen oxide (as NO_2) emissions					
Concentration (average)	ppm (volume)	8.95	9.57	9.97	9.50
Emission rate	lb/h	0.75	0.82	0.86	0.81
	kg/h	0.34	0.37	0.39	0.37
Emission factor	lb/ton	0.21	0.21	0.21	0.21
	kg/Mg	0.10	0.11	0.11	0.11
Hydrocarbon (as CH_4) emissions					
Concentration (average)	ppm (volume)	66.7	--	--	66.7
Emission rate	lb/h	2.01	--	--	2.01
	kg/h	0.91	--	--	0.91
Emission factor	lb/ton	0.56	--	--	0.56
	kg/Mg	0.28	--	--	0.28
Sulfur dioxide emissions					
Concentration (average)	ppm (volume)	14.1	17.6	17.3	16.3
Emission rate	lb/h	1.66	2.09	2.08	1.94
	kg/h	0.75	0.95	0.94	0.88
Emission factor	lb/ton	0.461	0.536	0.507	0.501
	kg/Mg	0.227	0.271	0.254	0.251

TABLE C-41. SUMMARY OF GASEOUS RESULTS
FACILITY D

Run number Date	Units	1 10-1-74	2 10-2-74	3 10-3-74	Average
Carbon monoxide emissions					
Concentration (average)	ppm (volume)	106	109	65	93
Emission rate	lb/h	7.16	9.63	5.24	7.34
	kg/h	3.25	4.37	2.38	3.33
Emission factor	lb/ton	1.56	2.47	1.19	1.74
	kg/Mg	0.77	1.25	0.60	0.87
Hydrocarbon as (CH_4) emissions					
Concentration (average)	ppm (volume)	2.91	7.34	11.52	7.26
Emission rate	lb/h	0.112	0.371	0.531	0.338
	kg/h	0.051	0.168	0.241	0.153
Emission factor	lb/ton	0.024	0.095	0.121	0.080
	kg/Mg	0.012	0.048	0.060	0.040
Sulfur dioxide emissions					
Concentration (average)	ppm (volume)	1.7	2.5	17.7	7.3
Emission rate	lb/h	0.25	0.49	3.16	1.30
	kg/h	0.11	0.22	1.43	0.59
Emission factor	lb/ton	0.054	0.126	0.718	0.299
	kg/Mg	0.026	0.063	0.358	0.149

TABLE C-42. SUMMARY OF PARTICULATE RESULTS STEEL FURNACES (UNITED STATES)

Facility	Sampling time min	Nominal furnace capacity Mg (ton)	Exhaust flowrate m^3/min (ft^3/min)	Stack temperature °C (°F)	Particulate emissions		
					kg/h (lb/h)	mg/Nm^3 (gr/dscf) Test	Average
G	60	27.2 (30)	1,948[a] (68,800)	-- --	-- --	9.15 (0.004)	14.6 (0.0064)
	60					5.72 (0.0025)	
	60					6.87 (0.003)	
	60					36.6 (0.016)	
H	60	29.9 (33)	2,180[a] (77,000)	-- --	-- --	4.58 (0.002)	5.73 (0.0025)
	60					6.87 (0.003)	
I	80	33.1 (36.5)	732 (25,857)	56 (133)	(0.05)	0.46 (0.0002)	3.97 (0.0017)
	80	33.1 (36.5)	729 (25,754)	59 (139)	(0.27)	2.75 (0.0012)	
	30	33.1 (36.5)	734 (25,850)	60 (140)	(0.85)	8.70 (0.0038)	
J	240	27.2 (30)	2,905 (102,600)	49 (120)	-- --	-- --	6.64 (0.0029)
K	88	5.4 (6)	310 (10,945)	68 (154)	(0.5549)	13.5 (0.0059)	16.0 (0.0070)
	88	5.4 (6)	301 (10,615)	63 (146)	(0.5130)	12.8 (0.0056)	
	88	5.4 (6)	299 (10,552)	65 (149)	(0.8613)	21.7 (0.0095)	

[a] Nominal.

[b] Dry standard.

Table C-43

FACILITY: G
SUMMARY OF VISIBLE EMISSIONS
Heat 1206

Type of Plant: Steel Foundry		Date: July 14, 1976	
Type of Discharge: Particulate		Height of Point of Discharge: 10-15 m	
Location of Discharge: Baghouse outlet		Height of Observation Point: ground level	
Distance from Observer to Discharge Point: 10-15 m		Duration: 155 min.	
Direction of Observer from Discharge Point:			
Descript. of Background: sky	Wind Direction: NW	Color of Plume: grey-white	
Descript. of Sky: clear	Wind Velocity: 3-7mph	Detached Plume:	

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	0929	0935	5	0.2	21	1129	1135	375	15.6
2	0935	0941	5	0.2	22	1135	1141	15	0.6
3	0941	0947	20	0.8	23	1141	1147	50	2.1
4	0947	0953	0	0.0	24	1147	1153	0	0.0
5	0953	0959	15	0.6	25	1153	1159	0	0.0
6	0959	1005	0	0.0	26	1159	1204	0	0.0
7	1005	1011	85	3.5	27				
8	1011	1017	95	4.0	28				
9	1017	1023	145	6.0	29				
10	1023	1029	525	21.9	30				
11	1029	1035	285	11.9	31				
12	1035	1041	55	2.3	32				
13	1041	1047	0	0.0	33				
14	1047	1053	10	0.4	34				
15	1053	1059	65	2.7	35				
16	1059	1105	60	2.5	36				
17	1105	1111	155	6.5	37				
18	1111	1117	150	6.3	38				
19	1117	1123	130	5.4	39				
20	1123	1129	190	7.9	40				

Sketch showing how opacity varied with time:

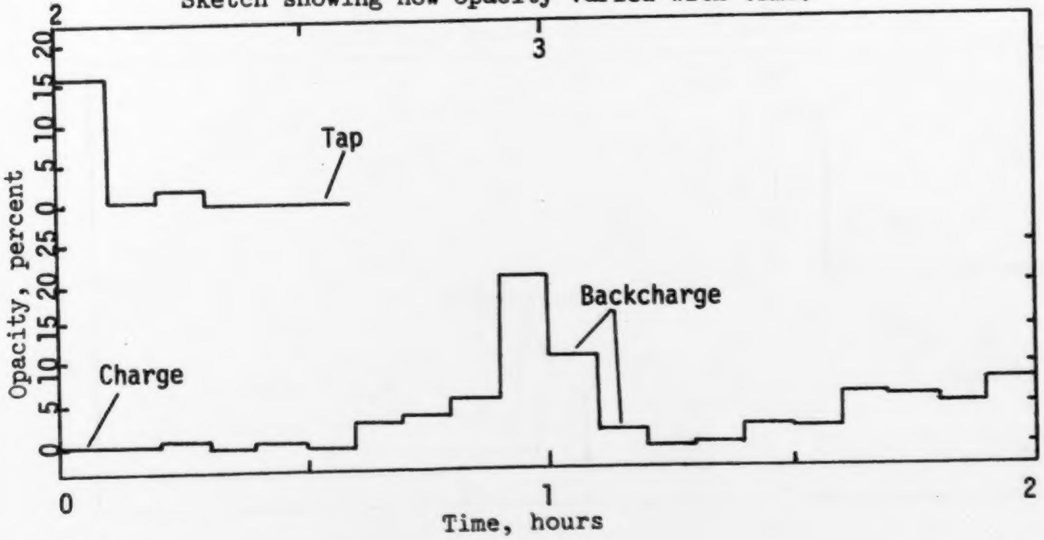


Table C-44

FACILITY: G

SUMMARY OF VISIBLE EMISSIONS

Heat 1206

Type of Plant: Steel Foundry Date: July 14, 1976

Type of Discharge: Particulate Height of Point of Discharge: 85 ft.

Location of Discharge: Roof Vent A Height of Observation Point: 75 ft.

Distance from Observer to Discharge Point: 50 ft. Duration: 159 min.

Direction of Observer from Discharge Point: SE of Stack

Descript. of Background: Dark wall Wind Direction: NW Color of Plume: Grey

Descript. of Sky: Partly Cloudy Wind Velocity: 3-7 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	0929	0935	30	1.2	21	1129	1135	0	0.0
2	0935	0941	0	0.0	22	1135	1141	0	0.0
3	0941	0947	0	0.0	23	1141	1147	0	0.0
4	0947	0953	0	0.0	24	1147	1153	0	0.0
5	0953	0959	0	0.0	25	1153	1159	0	0.0
6	0959	1005	0	0.0	26	1159	1205	310	12.9
7	1005	1011	0	0.0	27	1205	1208	0	0.0
8	1011	1017	0	0.0	28				
9	1017	1023	0	0.0	29				
10	1023	1029	0	0.0	30				
11	1029	1035	150	6.2	31				
12	1035	1041	45	1.9	32				
13	1041	1047	0	0.0	33				
14	1047	1053	0	0.0	34				
15	1053	1059	0	0.0	35				
16	1059	1105	0	0.0	36				
17	1105	1111	0	0.0	37				
18	1111	1117	0	0.0	38				
19	1117	1123	0	0.0	39				
20	1123	1129	0	0.0	40				

Sketch showing how opacity varied with time:

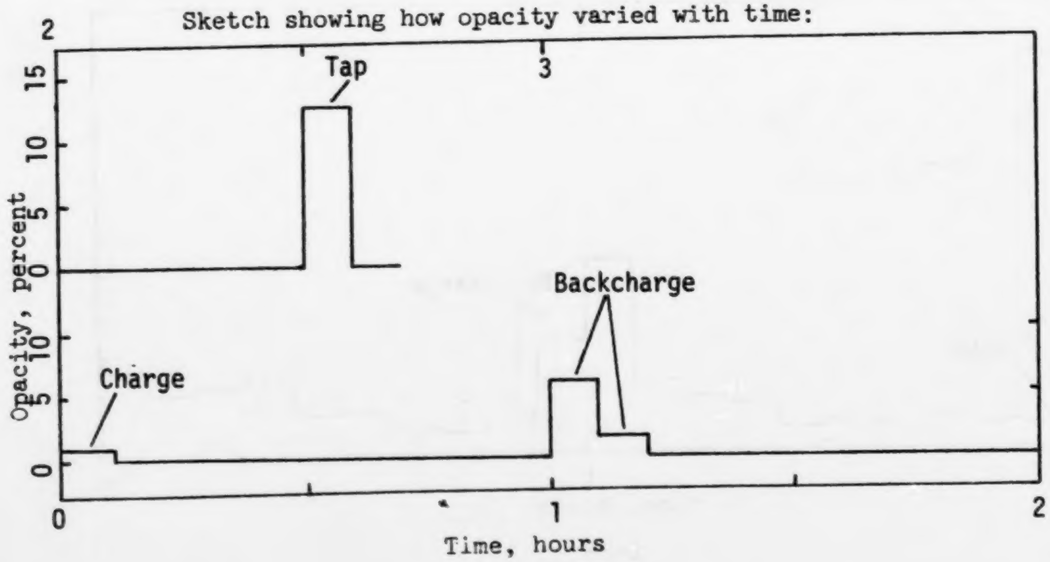


Table C-45

FACILITY: G

SUMMARY OF VISIBLE EMISSIONS

Heat 1206

Type of Plant: Steel Foundry Date: July 14, 1976
Type of Discharge: Particulate Height of Point of Discharge: 85 ft.
Location of Discharge: Roof Vent B Height of Observation Point: 75 ft.
Distance from Observer to Discharge Point: 25 ft. Duration: 159 min.
Direction of Observer from Discharge Point: SE of stack
Descript. of Background: Dark wall Wind Direction: NW Color of Plume: Grey
Descript. of Sky: Partly Cloudy Wind Velocity: 3-7 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	0929	0935	35	1.5	21	1129	1135	0	0.0
2	0935	0941	0	0.0	22	1135	1141	0	0.0
3	0941	0947	0	0.0	23	1141	1147	0	0.0
4	0947	0953	0	0.0	24	1147	1153	0	0.0
5	0953	0959	0	0.0	25	1153	1159	0	0.0
6	0959	1005	0	0.0	26	1159	1205	400	16.7
7	1005	1011	0	0.0	27	1205	1208	0	0.0
8	1011	1017	0	0.0	28				
9	1017	1023	0	0.0	29				
10	1023	1029	0	0.0	30				
11	1029	1035	190	7.9	31				
12	1035	1041	40	1.7	32				
13	1041	1047	0	0.0	33				
14	1047	1053	0	0.0	34				
15	1053	1059	0	0.0	35				
16	1059	1105	0	0.0	36				
17	1105	1111	0	0.0	37				
18	1111	1117	0	0.0	38				
19	1117	1123	0	0.0	39				
20	1123	1129	0	0.0	40				

Sketch showing how opacity varied with time:

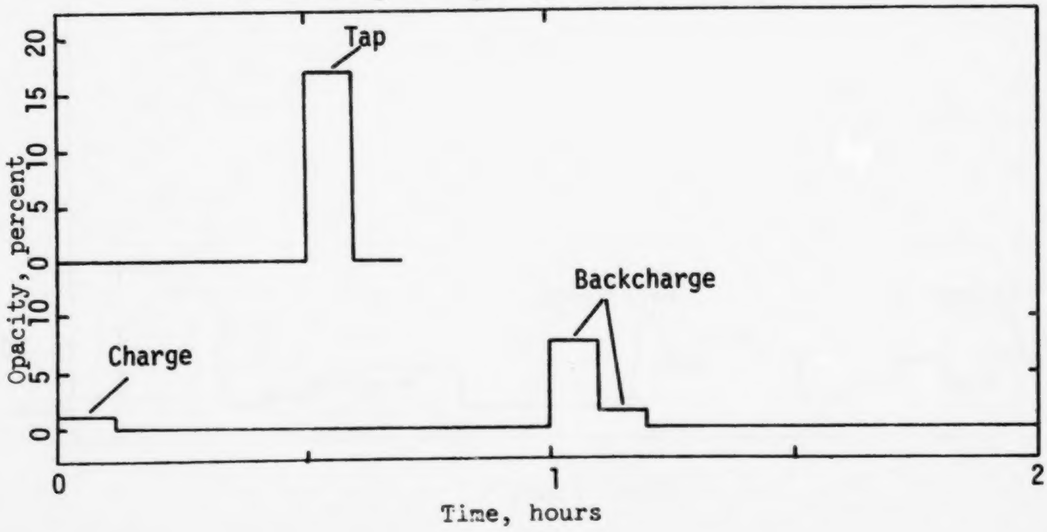


Table C-46

FACILITY: G
SUMMARY OF VISIBLE EMISSIONS
Heat 1207

Type of Plant: Steel Foundry Date: July 14, 1976
Type of Discharge: Particulate Height of Point of Discharge: 10-15 m
Location of Discharge: Baghouse Outlet Height of Observation Point: ground level
Distance from Observer to Discharge Point: 10-15m Duration: 135 min.
Direction of Observer from Discharge Point: ________
Descript. of Background: Sky Wind Direction: NW Color of Plume: grey white
Descript. of Sky: Clear to overcast Wind Velocity: 3-7 mph Detached Plume: ________

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1210	1216	90	3.8	21	1410	1416	0	0.0
2	1216	1222	30	1.3	22	1416	1422	0	0.0
3	1222	1228	90	3.8	23	1422	1425	0	0.0
4	1228	1234	40	1.7	24				
5	1234	1240	25	1.0	25				
6	1240	1246	100	4.2	26				
7	1246	1252	135	5.6	27				
8	1252	1258	75	3.1	28				
9	1258	1304	20	0.8	29				
10	1304	1310	0	0.0	30				
11	1310	1316	0	0.0	31				
12	1316	1322	0	0.0	32				
13	1322	1328	75	3.1	33				
14	1328	1334	45	1.9	34				
15	1334	1340	50	2.1	35				
16	1340	1346	30	1.3	36				
17	1346	1352	5	0.2	37				
18	1352	1358	205	8.5	38				
19	1358	1404	285	11.9	39				
20	1404	1410	30	1.3	40				

Sketch showing how opacity varied with time:

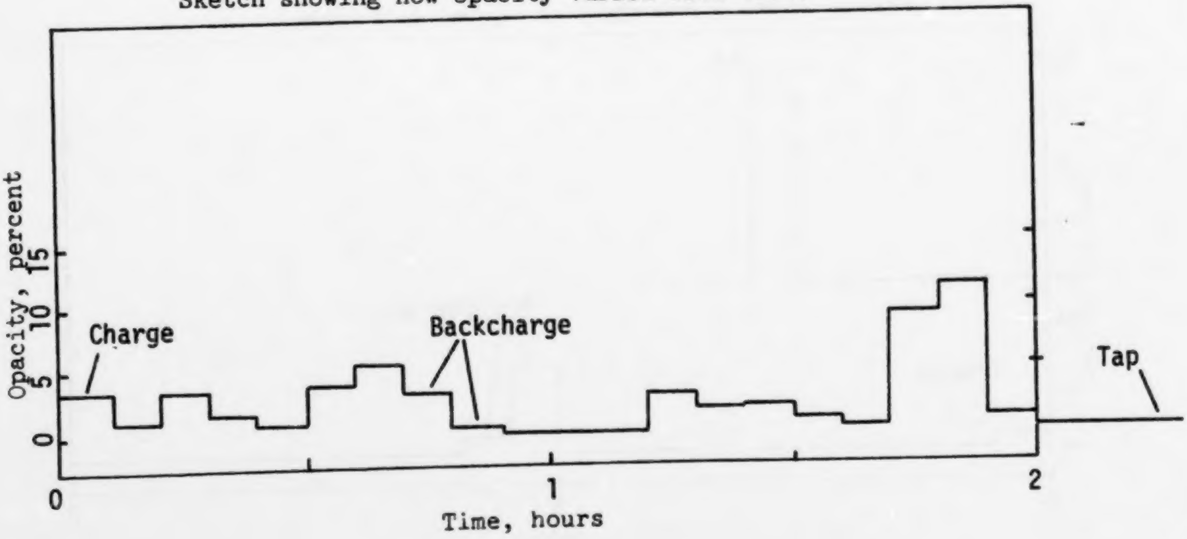


Table C-47

FACILITY: G

SUMMARY OF VISIBLE EMISSIONS

Heat 1207

Type of Plant: Steel Foundry Date: July 14, 1976

Type of Discharge: Particulate Height of Point of Discharge: 85 ft.

Location of Discharge: Roof Vent A Height of Observation Point: 75 ft.

Distance from Observer to Discharge Point: 50 ft. Duration: 136 min.

Direction of Observer from Discharge Point: SE of stack

Descript. of Background: Dark wall Wind Direction: NW Color of Plume: Grey

Descript. of Sky: Partly Cloudy Wind Velocity: 3-7 mph Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1210	1216	45	1.9	21	1410	1416	0	0.0
2	1216	1222	0	0.0	22	1416	1422	0	0.0
3	1222	1228	0	0.0	23	1422	1426	200	12.5
4	1228	1234	0	0.0	24				
5	1234	1240	0	0.0	25				
6	1240	1246	0	0.0	26				
7	1246	1252	0	0.0	27				
8	1252	1258	0	0.0	28				
9	1258	1304	135	5.6	29				
10	1304	1310	0	0.0	30				
11	1310	1316	0	0.0	31				
12	1316	1322	0	0.0	32				
13	1322	1328	0	0.0	33				
14	1328	1334	0	0.0	34				
15	1334	1340	0	0.0	35				
16	1340	1346	0	0.0	36				
17	1346	1352	0	0.0	37				
18	1352	1358	0	0.0	38				
19	1358	1404	0	0.0	39				
20	1404	1410	0	0.0	40				

Sketch showing how opacity varied with time:

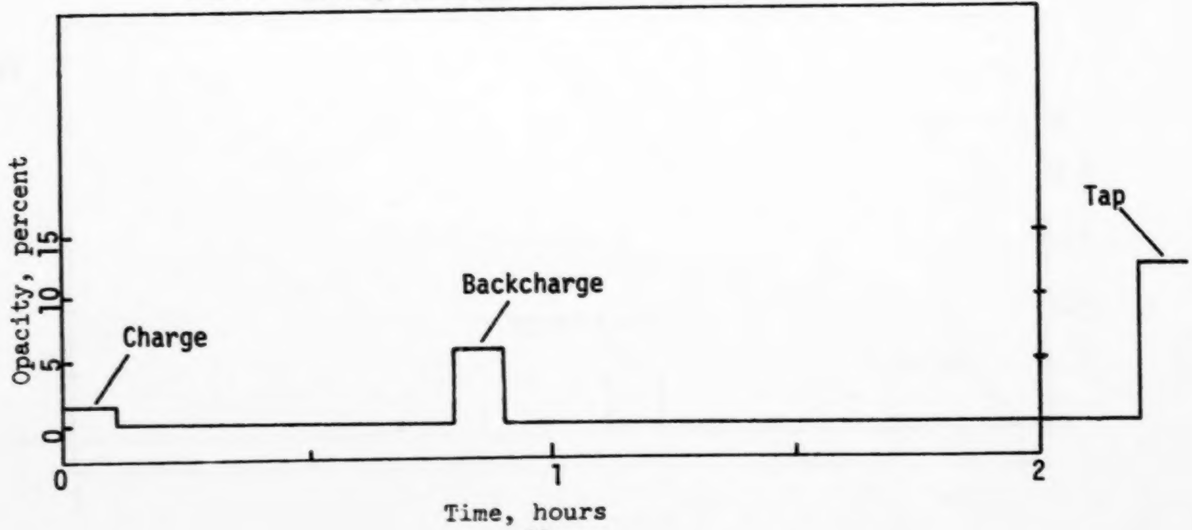


Table C-48

FACILITY: G
SUMMARY OF VISIBLE EMISSIONS
Heat 1207

Type of Plant: Steel Foundry
Date: July 14, 1976
Type of Discharge: Particulate
Height of Point of Discharge: 85 ft.
Location of Discharge: Roof Vent B
Height of Observation Point: 75 ft.
Distance from Observer to Discharge Point: 25 ft.
Duration: 136 min.
Direction of Observer from Discharge Point: SE of stack
Descript. of Background: Dark wall
Wind Direction: NW
Color of Plume: Grey
Descript. of Sky: Partly Cloudy
Wind Velocity: 3-7 mph
Detached Plume: No

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	1210	1216	10	0.4	21	1410	1416	0	0.0
2	1216	1222	0	0.0	22	1416	1422	0	0.0
3	1222	1228	0	0.0	23	1422	1426	385	24.1
4	1228	1234	0	0.0	24				
5	1234	1240	0	0.0	25				
6	1240	1246	0	0.0	26				
7	1246	1252	0	0.0	27				
8	1252	1258	0	0.0	28				
9	1258	1304	115	4.8	29				
10	1304	1310	0	0.0	30				
11	1310	1316	0	0.0	31				
12	1316	1322	0	0.0	32				
13	1322	1328	0	0.0	33				
14	1328	1334	0	0.0	34				
15	1334	1340	0	0.0	35				
16	1340	1346	0	0.0	36				
17	1346	1352	0	0.0	37				
18	1352	1358	0	0.0	38				
19	1358	1404	0	0.0	39				
20	1404	1410	0	0.0	40				

Sketch showing how opacity varied with time:

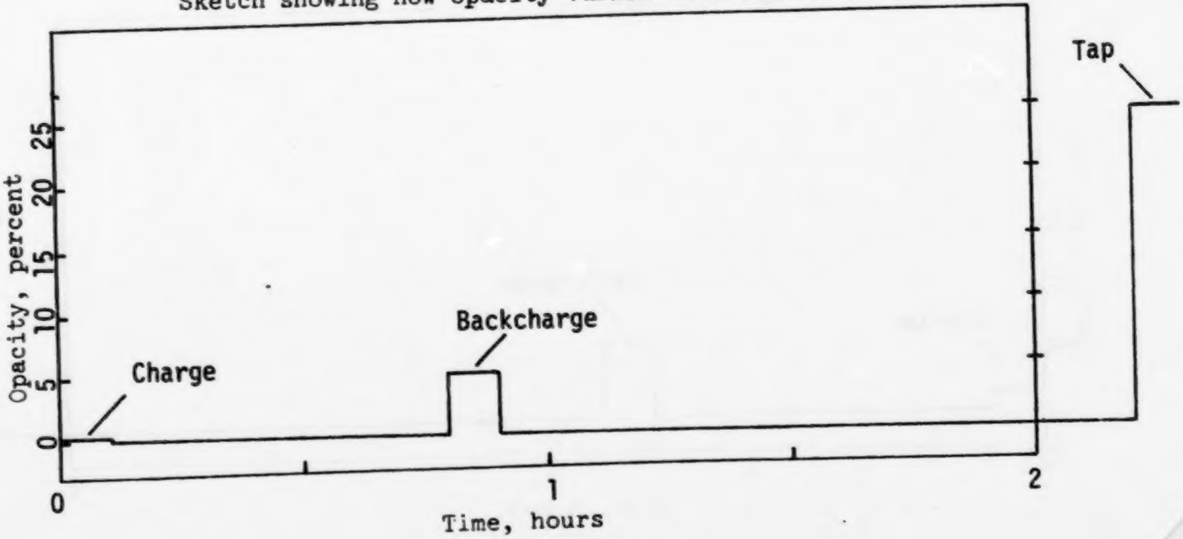


Table C-49

FACILITY: I
SUMMARY OF VISIBLE EMISSIONS
Heat E1-3251

Type of Plant: Steel Foundry Date: July 21, 1976
Type of Discharge: Stack Height of Point of Discharge: 20 m
Location of Discharge: Baghouse outlet Height of Observation Point: ground
Distance from Observer to Discharge Point: 30 m Duration: 222 min
Direction of Observer from Discharge Point: NE
Descript. of Background: Sky Wind Direction: Color of Plume:
Descript. of Sky: Overcast Wind Velocity: Detached Plume:

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	6:18		0	0.0	21	8:18		0	0.0
2	6:24		0	0.0	22	8:24		85	3.3
3	6:30		15	0.6	23	8:30		0	0.0
4	6:36		80	3.3	24	8:36		0	0.0
5	6:42		0	0.0	25	8:42		0	0.0
6	6:48		0	0.0	26	8:48		0	0.0
7	6:54		0	0.0	27	8:54		0	0.0
8	7:00		0	0.0	28	9:00		0	0.0
9	7:06		0	0.0	29	9:06		0	0.0
10	7:12		0	0.0	30	9:12		0	0.0
11	7:18		0	0.0	31	9:18		65	2.7
12	7:24		10	0.4	32	9:24		0	0.0
13	7:30		55	2.3	33	9:30		0	0.0
14	7:36		0	0.0	34	9:36		0	0.0
15	7:42		0	0.0	35	9:42		0	0.0
16	7:48		0	0.0	36	9:48		0	0.0
17	7:54		0	0.0	37	9:54		0	0.0
18	8:00		0	0.0	38				
19	8:06		0	0.0	39				
20	8:12		0	0.0	40				

Sketch showing how opacity varied with time:

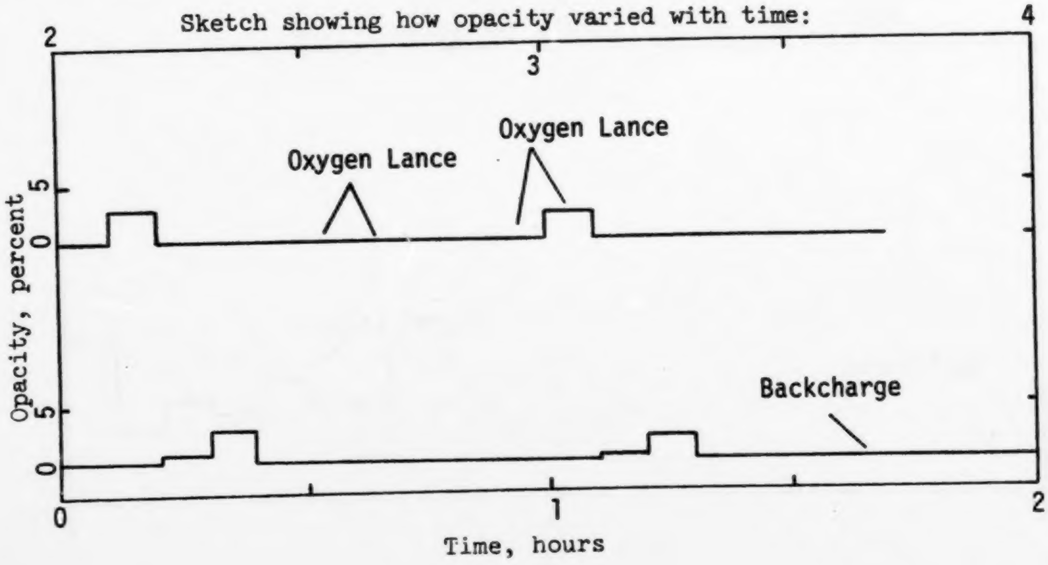


Table C-50

FACILITY: I

SUMMARY OF VISIBLE EMISSIONS
Heat E1-3251

Type of Plant: Steel Foundry Date: July 21, 1976
Type of Discharge: Roof Vent Height of Point of Discharge: 25 m
Location of Discharge: Roof of Building Height of Observation Point: 10 m
Distance from Observer to Discharge Point: 45 m Duration: 108 min.
Direction of Observer from Discharge Point: West
Descript. of Background: Building Wind Direction: variable Color of Plume:
Descript. of Sky: Overcast Wind Velocity: Detached Plume:

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	7:51		35	1.5	21				
2	7:57		0	0.0	22				
3	8:03	8:09	0	0.0	23				
4	8:20		0	0.0	24				
5	8:26		0	0.0	25				
6	8:32		0	0.0	26				
7	8:38		0	0.0	27				
8	8:44		30	1.3	28				
9	8:50		0	0.0	29				
10	8:56	9:02	10	0.4	30				
11	9:10		20	0.8	31				
12	9:16		115	4.8	32				
13	9:22		160	6.7	33				
14	9:28		100	4.2	34				
15	9:34		125	5.2	35				
16	9:40		75	3.1	36				
17	9:46		240	10.0	37				
18	9:55		0	0.0	38				
19					39				
20					40				

Last data set consists of 16 readings

Sketch showing how opacity varied with time:

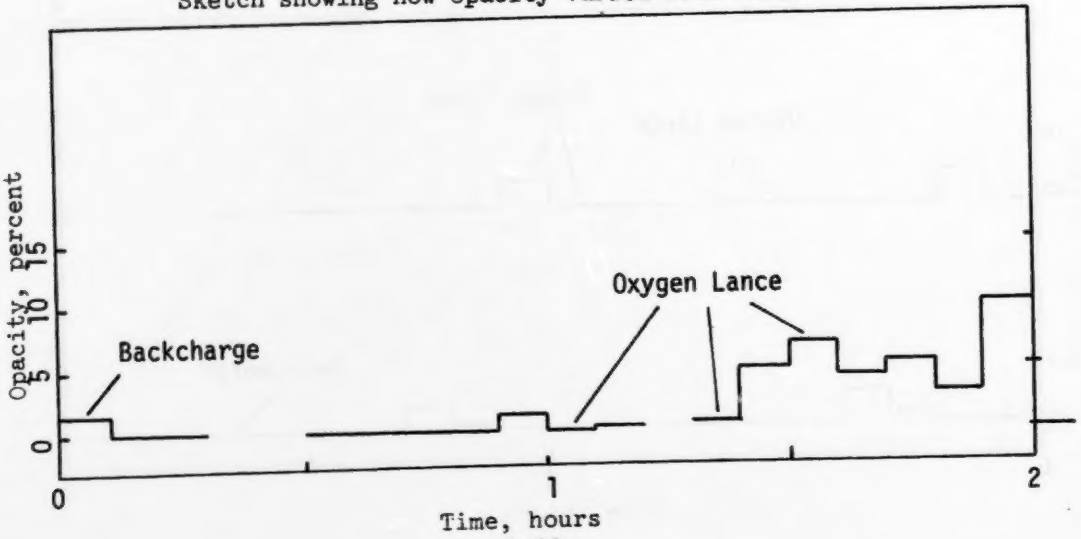


Table C-51

FACILITY: I

SUMMARY OF VISIBLE EMISSIONS

Heat E1-3255

Type of Plant: Steel Foundry Date: July 22, 1976
Type of Discharge: Stack Height of Point of Discharge: 20 m
Location of Discharge: Baghouse outlet Height of Observation Point: ground
Distance from Observer to Discharge Point: 30 m Duration: 216 min.
Direction of Observer from Discharge Point: West
Descript. of Background: Sky Wind Direction: variable Color of Plume:
Descript. of Sky: Overcast Wind Velocity: Detached Plume:

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	7:53		0	0.0	21	9:53		0	0.0
2	7:59		0	0.0	22	9:59		0	0.0
3	8:05		0	0.0	23	10:05		0	0.0
4	8:11		0	0.0	24	10:11		95	4.0
5	8:17		0	0.0	25	10:17		0	0.0
6	8:23		50	2.1	26	10:23		0	0.0
7	8:29		0	0.0	27	10:29		0	0.0
8	8:35		0	0.0	28	10:35		0	0.0
9	8:41		0	0.0	29	10:41		0	0.0
10	8:47		0	0.0	30	10:47		0	0.0
11	8:53		0	0.0	31	10:53		0	0.0
12	8:59		0	0.0	32	10:59		0	0.0
13	9:05		0	0.0	33	11:05		0	0.0
14	9:11		0	0.0	34	11:11		55	2.3
15	9:17		45	1.9	35	11:17		0	0.0
16	9:23		0	0.0	36	11:23		0	0.0
17	9:29		0	0.0	37				
18	9:35		0	0.0	38				
19	9:41		0	0.0	39				
20	9:47		0	0.0	40				

Sketch showing how opacity varied with time:

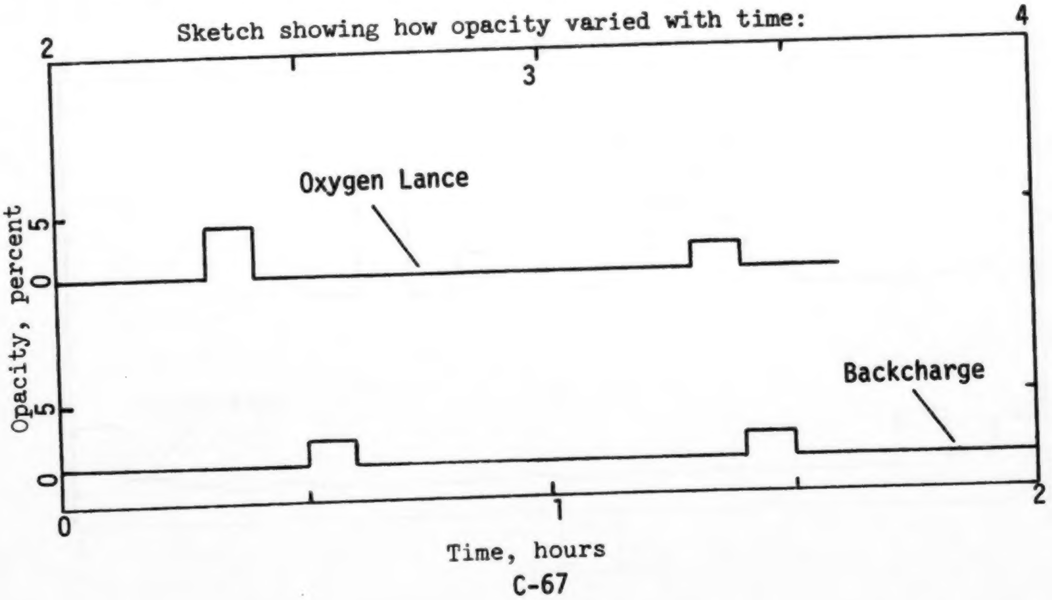


Table C-52

FACILITY: I

SUMMARY OF VISIBLE EMISSIONS
Heat El-3255

Type of Plant: Steel Foundry Date: July 22, 1976
Type of Discharge: Electric Arc Furnace Height of Point of Discharge: 25 m
Location of Discharge: Roof Vent Height of Observation Point: 10 m
Distance from Observer to Discharge Point: 45 m Duration: 210 min.
Direction of Observer from Discharge Point: West
Descript. of Background: Building Wind Direction: variable Color of Plume:
Descript. of Sky: Overcast Wind Velocity: Detached Plume:

SUMMARY OF TIME AND AVERAGE OPACITY

Set No.	Start	End	Sum	Avg.	Set No.	Start	End	Sum	Avg.
1	7:56		90	3.8	21	9:56		5	0.2
2	8:02		25	1.0	22	10:02		5	0.2
3	8:08		110	4.6	23	10:08		0	0.0
4	8:14		0	0.0	24	10:14		0	0.0
5	8:20		0	0.0	25	10:20		0	0.0
6	8:26		0	0.0	26	10:26		25	1.0
7	8:32		5	0.2	27	10:32		120	5.0
8	8:38		0	0.0	28	10:38		165	6.9
9	8:44		0	0.0	29	10:44		35	1.5
10	8:50		0	0.0	30	10:50		0	0.0
11	8:56		5	0.2	31	10:56		0	0.0
12	9:02		0	0.0	32	11:02		85	3.5
13	9:08		0	0.0	33	11:08		0	0.0
14	9:14		0	0.0	34	11:14		235	9.8
15	9:20		0	0.0	35	11:20	11:26	0	0.0
16	9:26		10	0.4	36				
17	9:32		0	0.0	37				
18	9:38		10	0.4	38				
19	9:44		25	1.0	39				
20	9:50		135	5.6	40				

Sketch showing how opacity varied with time:

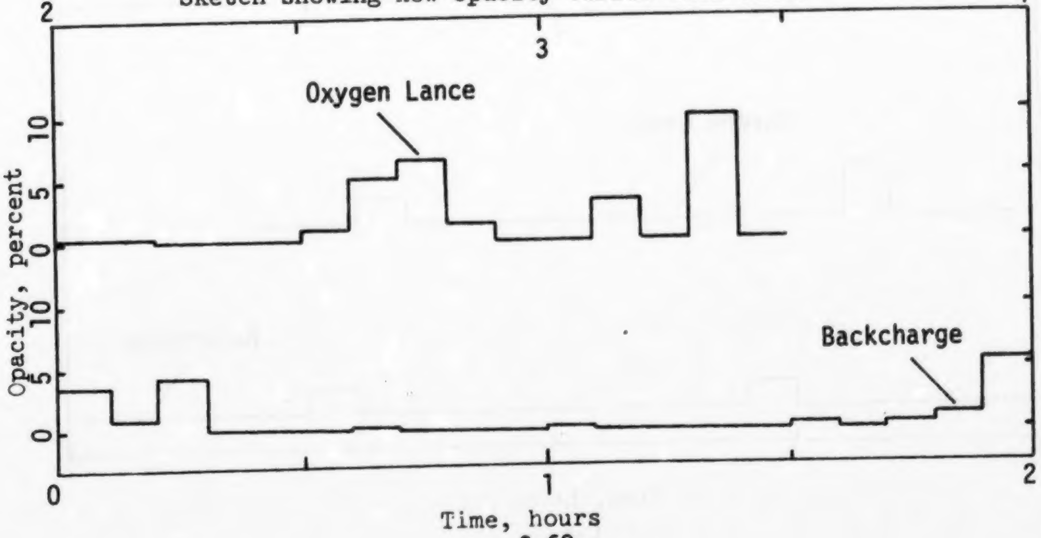


TABLE C-53. SUMMARY OF TAPPING PIT ENCLOSURE EMISSIONS
(9.1-Mg furnace)

			Method 22 results						Method 9 results (indoors)					
			Observer 1			Observer 2			Observer 1			Observer 2		
									Percent			Percent		
Date	Operation	Time (approximate)	Accumulated time min:sec	Emission time min:sec	Percent emission time	Accumulated time min:sec	Emission time min:sec	Percent emission time	Low	High	Avg.	Low	High	Avg.
5-30-79	Reladle[a]	10:05 - 10:06	1:05	0:59	91	1:08	1:08	100	--	--	--	--	--	--
5-30-79	Tap[a]	10:37 - 10:40	3:06	3:03	98	2:55	1:10	40	40	70	55	30	55	47
5-31-79	Tap[b]	9:30 - 9:32	2:27	0:37	25	2:29	0:24	16	0	20	6	0	40	11
5-31-79	Reladle[b]	1:35 - 1:37	1:49	0:42	39	1:45	0:33	31	--	--	--	--	--	--
5-31-79	Tap[b]	2:05 - 2:07	2:26	0:44	30	2:19	0:42	30	0	20	7	0	30	14

[a] Read at level of tapping spout.

[b] Read 1.8 m above level of tapping spout/pit enclosure roof.

C.5 REFERENCES FOR APPENDIX C

1. Air Pollution Emission Test: John Deere Tractor Works, Waterloo, Iowa. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-1. June 1974.

2. Source Sampling: John Deere Tractor Works, East Moline, Illinois. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 74-GFE-2. July 1974.

3. Air Pollution Emission Test: The Gleason Works, Rochester, New York. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-4. January 1975. 85 p.

4. Air Pollution Emission Test: The Paxton-Mitchell Plant, Omaha, Nebraska. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 75-GFE-3. February 1975. 173 p.

5. Letter and attachment from Hevey, L. A., State of Wisconsin Department of Natural Resources, to Georgieff, N. T., EPA. November 21, 1974. Report of source test at Beloit Corporation, Beloit, Wis.

6. Letter and attachment from Cropper, W. V., American Society for Testing and Materials, to Ajax, R. J., EPA. June 27, 1974. Submission of Draft D 2928 Report.

7. Telecon. Georgieff, N. T., EPA, to Bencus, H., The Gleason Works. February 20, 1980. Information on carbon injection via pressure lancing.

8. Memo from McCarley, J. E., Jr., EPA, to Georgieff, N. T., EPA. December 3, 1974. State of Wisconsin Test Report, Beloit Corporation, Beloit, Wisconsin.

9. Memo from Kelly, W. E., EPA, to Georgieff, N. T., EPA. July 19, 1974. Gray iron foundry data contained in ASTM D-2928 Report.

10. Memo from McCarley, J. E., Jr., EPA, to Georgieff, N. T., EPA. July 19, 1974. Gray iron foundry test ASTM D-2928 Report.

11. Letter from Wasem, J. W., American Steel Foundries, to Goodwin, D. R., EPA. June 18, 1976. Response to Section 114 letter on emission test results.

12. Allegheny County Health Department. Source Test of Baghouse on Steel Electric Arc Furnace at Bucyrus-Erie, Glassport, Pennsylvania. Pittsburgh, Pennsylvania. May 1975.

13. Telecon. Glenn, D., Buckeye Steel Casting Company, to Georgieff, N. T., EPA. September 18, 1976. Information on source tests at Buckeye Steel Casting Co.

14. Memo and attachments from Spawn, P., GCA/Technology Division, to EAF file. September 16, 1977. 16 p. Report of September 1977 plant visit to Hensley Industries, Inc., Dallas, Tex.

15. Telecon. Welzel, K., Landesanstalt fur Immissions und Bodennutzungsschutz des Landes Nordrhein-Westfalen, to Georgieff, N. T., EPA. June 10, 1976. Information on source test at German steel EAF.

16. Letter and attachments from Welzel, K., Landesanstalt fur Immissions und Bodennutzungsschutz des Landes Nordrhein-Westfalen, to Georgieff, N. T., EPA. June 16, 1976. Information on source tests at German steel EAF's.

17. Letter from Rohrick, Thyssen Giesserei AG, to N. T. Georgieff, EPA. June 24, 1976. Information on source tests at German steel EAF's.

18. Letter from Berton, D., Air Industrie, to Georgieff, N. T., EPA. June 18, 1976. Information on French foundry EAF's.

19. Letter from Bozzetti, M. A., Air Industrie, S.P.A., to Georgieff, N. T., EPA. March 4, 1976. Information on Italian foundry EAF's.

20. Letter and attachments from Mitrick, S. F., American Steel Foundries, to Goodwin, D. R., EPA. October 26, 1976. Information on steel foundry EAF source tests.

21. Memo from McCarley, J. E., Jr., EPA, to Cuffe, S. T., EPA. December 27, 1979. Review of EAF foundry test reports.

22. Memo and attachments from Shepherd, J. L., Buckeye Steel Castings, to Georgieff, N. T., EPA. December 11, 1979. Information on steel foundry EAF source test.

23. Memo and attachments from Harrison, R. T., and D. Holzschuh, EPA, to McCarley, J. E., Jr., EPA. July 26, 1976. Trip report of visible emission observations of an EAF at American Steel Foundry.

24. Memo and attachments from Harrison R. T., EPA, to McCarley, J. E., Jr., EPA. August 17, 1976. Trip to observe visible emissions of a steel foundry EAF.

25. Memo and attachment from Georgieff, N. T., EPA, to Spawn, P., GCA/Technology Division. March 15, 1978. Information on flowrates.

26. Fennelly, P. F. and P. D. Spawn. Air Pollutant Control Techniques for Electric Arc Furnaces in the Iron and Steel Foundry Industry. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. EPA-450/2-78-024. June 1978. 221 p.

27. Emission Test Report: Armco Steel, Torrance, California. U.S. Environmental Protection Agency. Research Triangle Park, N.C. EMB Report No. 79-ELC-6. May 1979.

APPENDIX D

EMISSION MEASUREMENT AND CONTINUOUS MONITORING

D.1 EMISSION MEASUREMENT METHODS

D.1.1 Control Device Exhaust

Particulate emissions were measured at six iron foundry electric arc furnaces (EAF's) and five steel-producing EAF's. Five of the iron foundry EAF tests were conducted using EPA Reference Method 5 (Appendix A 40 CFR Part 60). The sixth iron foundry EAF test was conducted using a modified version of EPA Reference Method 5 where an additional in-stack filter was added to the standard Method 5 sampling configuration, fewer than the required minimum number of traverse points were used, and a water wash of the probe was added in addition to the acetone wash. However, the data are judged to be reasonably close to those obtained by a standard Method 5. The five steel-producing EAF particulate results were obtained from industry representatives. These were reportedly obtained using EPA Reference Method 5. EPA did not review the detailed emission test reports. Visible emission observations were made at the control system exhaust at four of the iron-producing EAF's and two of the steel-producing EAF's following EPA Reference Method 9 (Appendix A 40 CFR Part 60).

D.1.2 Visible Emission at the Shop Roof Vent or Monitor

Visible emission observations were made at the shop roof vent or monitor of three of the iron-producing EAF's and two of the steel-producing EAF's. Except for one plant where a modified version of Method 9 was used, EPA Reference Method 9 was followed for the testing. A modified Method 9 was used at one plant because of the configuration of the plant. In this case, the observers read visible emissions from a position approximately perpendicular to the roof monitor.

D.2 MONITORING SYSTEMS AND DEVICES

D.2.1 Opacity Monitoring Systems

The monitoring systems that are adequate for monitoring opacity from control system exhausts from other stationary sources, such as steel plant electric arc furnaces, are described by performance specifications contained in Appendix B of 40 CFR 60 Federal Register, October 6, 1975. They are technically feasible for control systems generally employed at foundry electric arc furnaces. In a case where condensed moisture would be present in the control system exhaust, monitoring of opacity would not be applicable; therefore, another operating parameter would need to be monitored as an indication of emission control.

Equipment and installation costs for opacity monitoring are estimated to be about $18,000 to $20,000 per site. Annual operating costs which include the recording and reducing of the data are estimated at about $8,000 to $9,000 per site. Some savings in operating costs may be achieved if multiple systems are required at a given facility.

D.2.2 Exhaust Hood Volumetric Flow Monitoring Systems

The exhaust hood volumetric monitoring system employed will depend on plant configuration. EPA experience with field-proven, continuous volumetric flow monitoring systems is limited. Two EPA Office of Research and Development sponsored reports indicate that several flow monitoring systems are available which can meet accuracy requirements of 10 percent.[1,2] Because of varying duct configurations, in situ calibration is needed. The Emission Measurement Branch (EMB), Emission Standards and Engineering Division (ESED), Office of Air Quality Planning and Standards (OAQPS), Environmental Protection Agency, installed one monitor in a ferroalloy plant.[3] This test program was suspended after it became apparent that the probe could not withstand the severe corrosive and temperature environment. This problem appears to be a correctable physical limitation. Equipment and installation costs are estimated to range between $18,000 and $25,000 per site. Annual operating costs, which include recording and reducing of data, are estimated at $8,000 to $9,000 per site. Some savings in operating and equipment costs should be achieved if multiple systems are required at a given facility.

D.3 PERFORMANCE TEST METHODS

Consistent with the data base upon which the new source standard has been developed, the recommended performance test method for particulate matter is EPA Reference Method 5 (Appendix A 40 CFR Part 60, as amended August 18, 1977). In order to perform Reference Method 5, EPA Reference Methods 1 through 4 must also be employed.

Subpart A of 40 CFR Part 60 requires that affected facilities which are subject to new source standards must be constructed such that sampling ports adequate for the performance test are provided. Platforms, access, and utilities necessary to perform testing at those ports must be provided.

Sampling cost for performing a test of three Reference Method 5 runs is estimated to range from $9,000 to $12,000.

The recommended performance test method for visible emissions is EPA Reference Method 9 (Appendix A 40 CFR Part 60, as amended November 12, 1974).

D.4 REFERENCES FOR APPENDIX D

1. Brooks, E. F., E. C. Beder, C. A. Flegal, D. J. Luciani, and R. Williams. Continuous Measurement of Total Gas Flowrate from Stationary Sources. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. EPA-650/2-75-020. February 1975. 248 p.

2. Brooks, E. F. and R. L. Williams. Flow and Gas Sampling Manual. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Publication No. EPA-600/2-76-203. July 1976. 93 p.

3. McKendree, J. R. Instrument Evaluation Test on Brandt Industries DP 2711 Flow Monitor. U.S. Environmental Protection Agency. Research Triangle Park, N.C. Contract No. 68-02-2818, Work Assignment No. 11. Project No. 78-FEA-15. April 1979. 72 p.

United States
Environmental Protection
Agency

Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park NC 27711

Official Business
Penalty for Private Use
$300

Publication No. EPA-450/3-80-020a

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

If your address is incorrect, please change on the above label; tear off; and return to the above address.
If you do not desire to continue receiving this technical report series, CHECK HERE ☐ ; tear off label; and return it to the above address.

14
896